SOME INTRINSIC FACTORS AFFECTING SEED PRODUCTION IN BALSAM FIR

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CHAPTER 5

INTRINSIC FACTORS AFFECTING SEED PRODUCTION OVER A PERIOD OF YEARS

The results presented in Chapters 3 and 4 have shown that the trees in the sample stand and the more-intensively studied sample trees support the observations of others (Morris, 1951; Blais, 1952; Greenbank, 1963; Hughes 1967) to the effect that balsam fir tends to bear cones biennially. However, biennial bearing does not occur on all trees capable of bearing (Table 3.1 and Table 4.18), and some trees bear some cones in successive years. From this it seems probable that each tree, once it has flowered, retains the capacity to produce flowers each year. In order to discover whether or not intrinsic factors exist which have an influence on flower production in different years, it is first necessary to investigate flower-bud formation and its relation to formation of other kinds of buds. Following this, the numbers of buds of different kinds produced in different years will be studied and related, where possible to other factors such as number of shoots and shoot length.

5.1 BUD DEVELOPMENT IN BALSAM FIR

Shoot and bud collections in 1967, 1968 and 1969 facilitated observations of bud development. Details of procedures used were described in Section 2.6 D. In 1967, buds and shoots were collected, usually weekly throughout the growing season from trees 144 and 147. Material was obtained from trees 1 and 2 in 1968 and from trees 13, 144, 197 and 324 in 1969. Some experimental procedures were used in 1968 and 1969, to determine the effects of various kinds of bud removal on the development of shoots and buds remaining.

A. Terminal and Subterminal Buds

The development of the terminal buds of balsam fir is essentially the same as that described for Abies concolor Lindl. & Gord. by Parke (1959). The timing is, however, somewhat different, as would be expected even for the same species growing in widely separated geographical regions. The first growth phase of the telescoped shoot within the terminal bud of the previous year begins in mid April and continues until mid July. For four or five weeks, growth of the telescoped shoot occurs within the confines of the terminal bud scales. However, these scales are progressively forced aside and their overarching tips straightened as bud swelling occurs. The old terminal bud bursts in mid to late May at about the time of pollination and thus at a similar time to lateral vegetative buds (Powell, 1970). Usually, however, the terminal buds burst one or two days earlier than lateral vegetative buds on the same shoot. At this stage most shoots have extended to between 0.5 and 1.0 cm in length, a four-fold or five-fold increase over the resting-stage length.

Parke (1959) stated that the apical meristem remains essentially inactive in Abies concolor during the early phase of shoot elongation. In balsam fir, serial sections have shown two or three cells in each shoot apex to be dividing in early and mid May, thus showing some activity. About one week before the bud-bursting stage, production of cataphyll primordia begins around the base of the apical meristem. Production of cataphylls continues from the enlarging shoot apex until the end of the shoot-elongation phase in mid July. By that time the cataphylls form several layers overarching the shoot apex, which has become distinctly conical in shape, rather than the broad mound shape of the resting stage.

Parke (1959) did not include information on initiation of subterminal buds in Abies concolor, and details of subterminal-bud development appear to be lacking for other species. In balsam fir, subterminal bud primordia were visible in transverse sections of the developing shoot at the time of bud-bursting in 1969 (May 19-21). Figure 5.1 A shows bud primordia on opposite sides of the main shoot axis: each is situated in the axil of one of the first-formed cataphylls. The section shown is from a shoot developing from a subterminal bud of the previous year. Such shoots rarely form more than two laterally situated subterminal buds. Main shoots, however, often produce three (and rarely four) subterminal buds. A section from such a shoot, collected one week after bud bursting is shown in Fig 5.1 B. The third bud (in this case, the earliest initiated) is situated on the lower side of the shoot. It can be seen that cataphyll primordia have been produced by the subterminal bud primordia. This development continues as for the terminal bud. The subterminal buds, being subtended by scales produced at the level of the lowest terminal bud scales, remain within the scale complex of the terminal bud and thus, in a sense, form a terminal unit at the apex of the shoot.

In most terminal and subterminal buds, production of needle primordia begins in late July and continues until late September. A new telescoped shoot is thus formed within the bud scales, which grow to accomodate it. The shoot is always surmounted by the apical meristem, which gradually decreases in size and height as needle-primordial production continues. By late September the shoot apex assumes a low mound-like shape. During late August and early September a crown forms across the base of the telescoped shoot thus separating it from the portion of the axis which bears the bud scales. Copious resin is exuded from

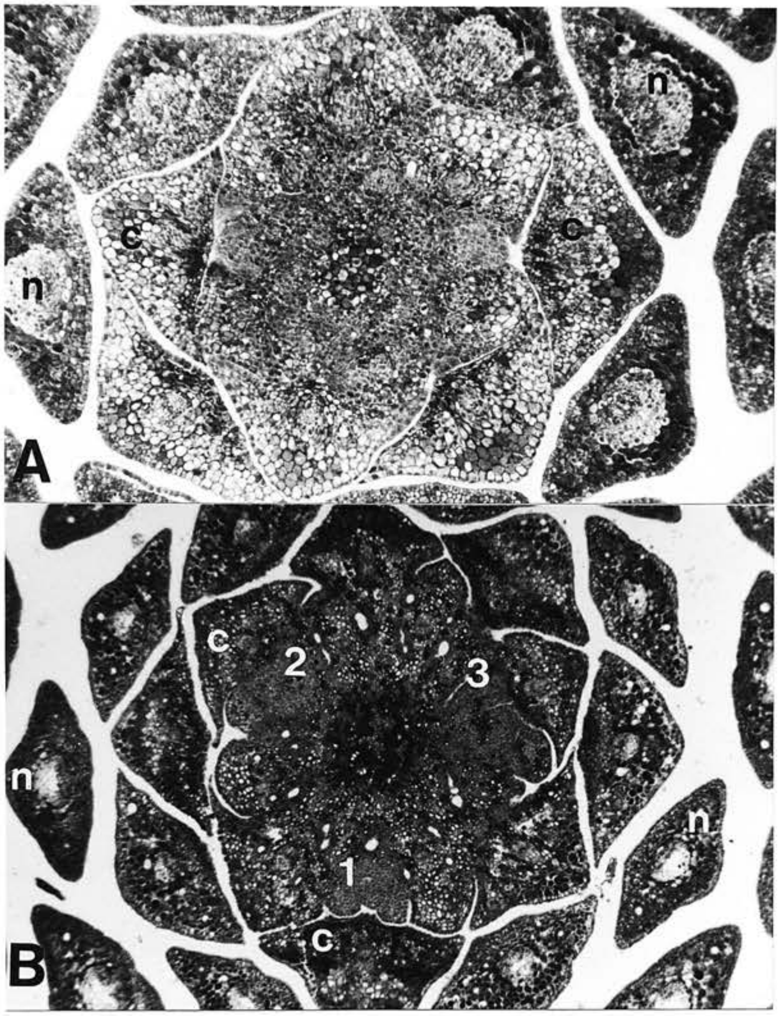

Figure 5.1. Transverse sections through the lower portions of newly developing terminal buds showing initiating subterminal buds, tree 13: (A) subterminal-bud primordia at either side of the shoot, 21 May 1969, x 112; (B) subterminal-bud primordia at three points around the axis, bud 1, in the underside position, is the most proximally situated and shows prophyll development, only the proximal portions of buds 2 and 3 are shown, 4 June 1969, x 45; main axis cataphyll (c), needle (n).

the bud scales and thus the overwintering bud is covered by a thick resinous layer. The bud scales, when first initiated are white or pale green. By the end of the shoot-elongation phase, the outer ones have turned pale brown; these become dark brown by late August but the inner scales remain largely devoid of colour.

Some terminal buds on weaker shoots fail to develop past the cataphyll-production stage, but such cessation of development is more common amongst sub-terminal buds (Figs. 5.2 A, B) on weaker shoots.

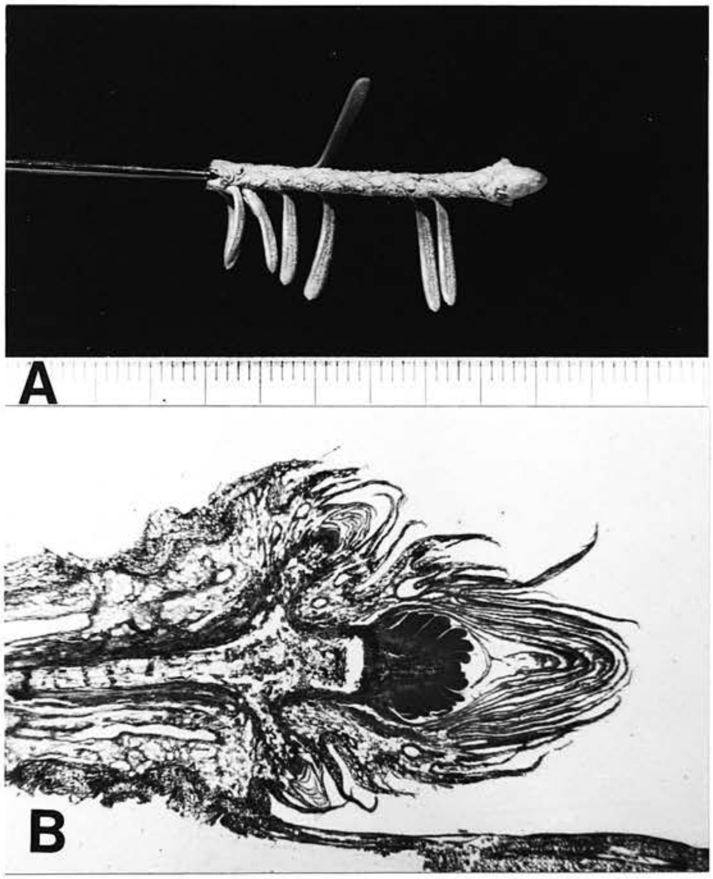

Figure 5.2. Shoots with a developed terminal bud and two non-developed sub-terminal buds, tree 1, October 1969: (A) entire shoot, most needles removed, scale in mm; (B) longitudinal section showing developed needle primordia on the main-shoot apex in the terminal bud, while development on the subterminal apices is limited to cataphylls, x 22.5.

B. Lateral Buds

i. On shoots in the female zone

Transverse serial sections of developing shoots in buds formed in 1968 provided information on initiation of lateral buds in the female zone. Collections were made on April 9, 21, May 2, 13, 21, 27 and June 4 from each of four trees in the spring of 1969. Bud primordia were clearly evident in material collected May 13, about one week before bud-bursting, from 13, and on May 21 on the other trees. At this stage the primordium is roughly wedge-shaped, with a flat surface opposite the subtending needle (Fig. 5.3 A). The large-celled tissue of the primordium extends about two-thirds of the distance to the pith. At the proximal end (with respect to the shoot) of the primordium, where the needle tissues join those of the shoot, the primordium swells slightly on either side of the base of the needle. At the distal end, some 100 microns from the needle base, a circular zonation is evident in the primordial tissues, and the surface of the primordium is more curved in nature and is more deep-seated, being covered at the sides by cortical cells, often with multicellular hairs. On some trees hairs extend from the cortical tissues at either side and cover the primordium surface (Fig. 5.3 B).

Prophylls were evident on lateral-bud primordia on tree 13 on May 21 (Fig. 5.3 C) and on the other trees (bud-bursting on each of which occurred some three to five days later than on tree 13) on May 27. These form from the lateral tissues of the surface of the primordium and a mounded apical meristem forms in the centre. The prophylls extend proximally on either side of the base of the subtending needle indicating that the swellings visible one week earlier were portions of the prophyll primordia. Figure 5.3 C shows that tissues in the lower central region of the primordium were differentiating.

Later sections showed a rapid increase in the numbers of cataphylls produced around the bud apex.

Where more than one bud primordium was found on a shoot, they always were in a similar stage of development, but a more proximally situated bud

Figure 5.3. Initiation of upper lateral buds: (A) bud primordium in the cortex of the shoot, tree 13, 13 May 1969; (B) distal side of a bud primordium covered by multicellualr cortical hairs, tree 324, 21 May 1969; (C) bud primordium with well-developed prophylls on either side, tree 13, 21 May 1969; all x 225, needle (n).

tended to be larger than a distally situated bud on the same shoot. The latter is initiated on a part of the shoot having a smaller diameter. The shoot, at this point is more deeply indented than nearer the base, and the developing bud seems to be more compressed by surrounding tissues and needles, giving the impression of more deepseatedness.

The buds are clearly visible, with the aid of a stereo microscope and after removal of the needles from the shoot, five to ten days after vegetative-bud bursting. They are pale green or colourless and consist of three or four relatively large cataphylls arched over a smooth pale gree, slightly dome-shaped apex. The two largest cataphylls (prophylls) are of similar size. The third largest cataphyll is always situated on the distal side of the bud. By mid June, when the vegetative shoots are about 1.5 cm long, the buds are more distinct, but still pale in colour. Their development is influenced by the shape of the space available to them between the still closely appressed needles. Thus, from above they appear somewhat triangular in shape (Fig. 5.4 A), but from the side, compression appears not to be a factor (Fig. 5.4 B). Figure 5.4 B clearly shows the translucent nature of the overarching scales and the hairs on the exposed parts of the shoot.

By late June, buds situated near the bases of the shoots can be seen without removal of needles. These buds are brown in colour, while those more distally situated, and still hidden by closely appressed needles, remain pale in colour. By the end of June all buds can usually be seen without parting of needles. The prophylls of each bud have assumed a deep red-brown colouring and have become broad at the base, narrowing to an accuminate tip. Inner cataphylls are less highly coloured, the degree of colouring on each lessens with distance

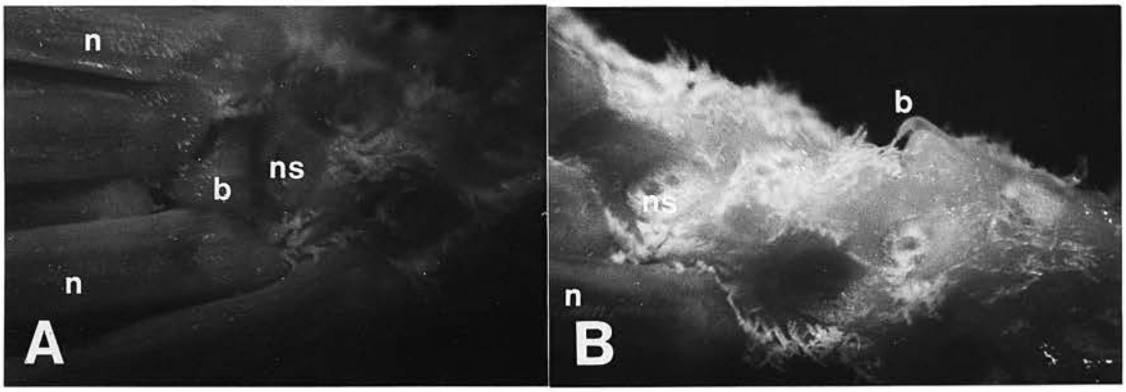

Figure 5.4. Upper lateral buds on shoots from female zones, June 16, 1967: (A) view from above, tree 144, x 37.5; (B) view from the side, tree 147, x 37.5; bud (b), needle (n), needle scar (ns).

from the midrib. The innermost cataphylls are pale green, as is the apex. At this stage, resin exudation begins among the cataphylls.

As in the case of terminal buds, cataphyll formation continues only until mid July when shoot elongation ceases. At this stage, the bud consists of a dome-shaped apex resting on a short, broad cataphyll-bearing axis. The bud scales can easily be removed to facilitate study of the apex: the axis provides a convenient means of handling the apex without damaging it (Fig. 5.5).

The development of lateral buds in the female zone may take one of three forms: a bud may develop vegetatively, reproductively, or may fail to develop more than cataphylls in the year of origin. In the latter case, the development may cease at any stage during cataphyll formation. Thus buds consisting of a few or many cataphylls overarching the apical meristem may occur. The meristems of the former are green in mid July, but in many buds they become brown by September. At that time the few scales have usually become very hard and have assumed the colour of the shoot. Because of this and their small size, they are hard to see.

Buds in which development is arrested after more cataphylls have been produced are naturally larger, but the cataphylls do not show any appreciable increase in size subsequent to mid July. The apical meristem within such a bud generally retains its green colour into the fall. Buds of each of the three main types have been observed in all normal lateral bud positions on the shoot, thus each bud produced has the capacity to become reproductive or vegetative. Under certain circumstances the capacity to develop during the year of origin is lost or arrested.

Lateral buds which develop vegetatively do so in a manner similar to the terminal vegetative buds. Needle primordia are produced from late July through to late September. These arise in a regular phyllotaxic pattern around the circumference of the shoot apex as small rounded mounds of tissue. As they develop they elongate and broaden and assume a slightly incurved shape. Each needle tends to cover the lower lateral half of the abaxial side of each of the two needles produced above it. Above the points of overlap each needle presents an exposed surface which is roughly rhombic in shape. The needle tip is, however, never pointed. A crown is formed below the new shoot during late August. The new telescoped shoot within a vegetative lateral bud tends to be roughly spherical in shape (Powell, 1970 (Appendix 16, Fig. 1 C, April 11)).

The early stages of differentiation of foliar primordia (bracts) in megasporangiate buds are similar to those for vegetative buds. However, in strobilus-bearing trees there is a marked tendency for vegetative buds to be formed close to the shoot apices, while megasporangiate buds are formed more proximally (see Section 5.2 D). Also, on any one tree, megasporangiate buds are larger at all stages of development than vegetative buds on the same shoot. The apical meristems in megasporangiate buds are larger and less conical at the end of the cataphyll-producing stage.

Figure 5.5 A shows how bract primordia encircle the base of the apex above the cataphyll-bearing region by early August. Bract initiation continues during August and September but ceases during early October. Increases in bract size occur until the end of October. These are accompanied by the development of a lanceolate and incurved shape. By early October the bracts begin to overgrow the apex; in many buds the apex is completely hidden by bracts at the end of October. Sections show no noticeable change in size or shape of the strobilus apex during late September and October. Mitotic figures are infrequent in the apex in early October, but frequent in the surrounding primordia. In late October, activity is lacking in the apex and infrequent in the primordia.

The drawings in Fig. 5.5 A show that both the strobilus and the axis beneath increase in size as development proceeds. Increase in axis size accommodates growth of the bud scales which it bears. During late August and early September a crown develops between the strobilus and the cataphyll-bearing portion of the axis.

Late August and early September is also the period during which ovuliferous-scale primordia are first initiated. An ovuliferous scale is developed on the base of each bract (except for one or two at the extreme base and apex of the strobilus). The first indication of ovuliferous-scale initiation is the development of a slight bulge at the median point of the adaxial surface of the base of the bract. Subsequent growth is rapid so that by the end of September ovuliferous scales cover the lower third of each bract. A section cut from a bud collected in mid October is shown in Fig. 5.6. Ovuliferous-scale primordia are evident in the axils of all but the most recently formed bracts.

Organization of cells within the ovuliferous scale is not generally apparent at the end of October. However, in one case a distinct circular

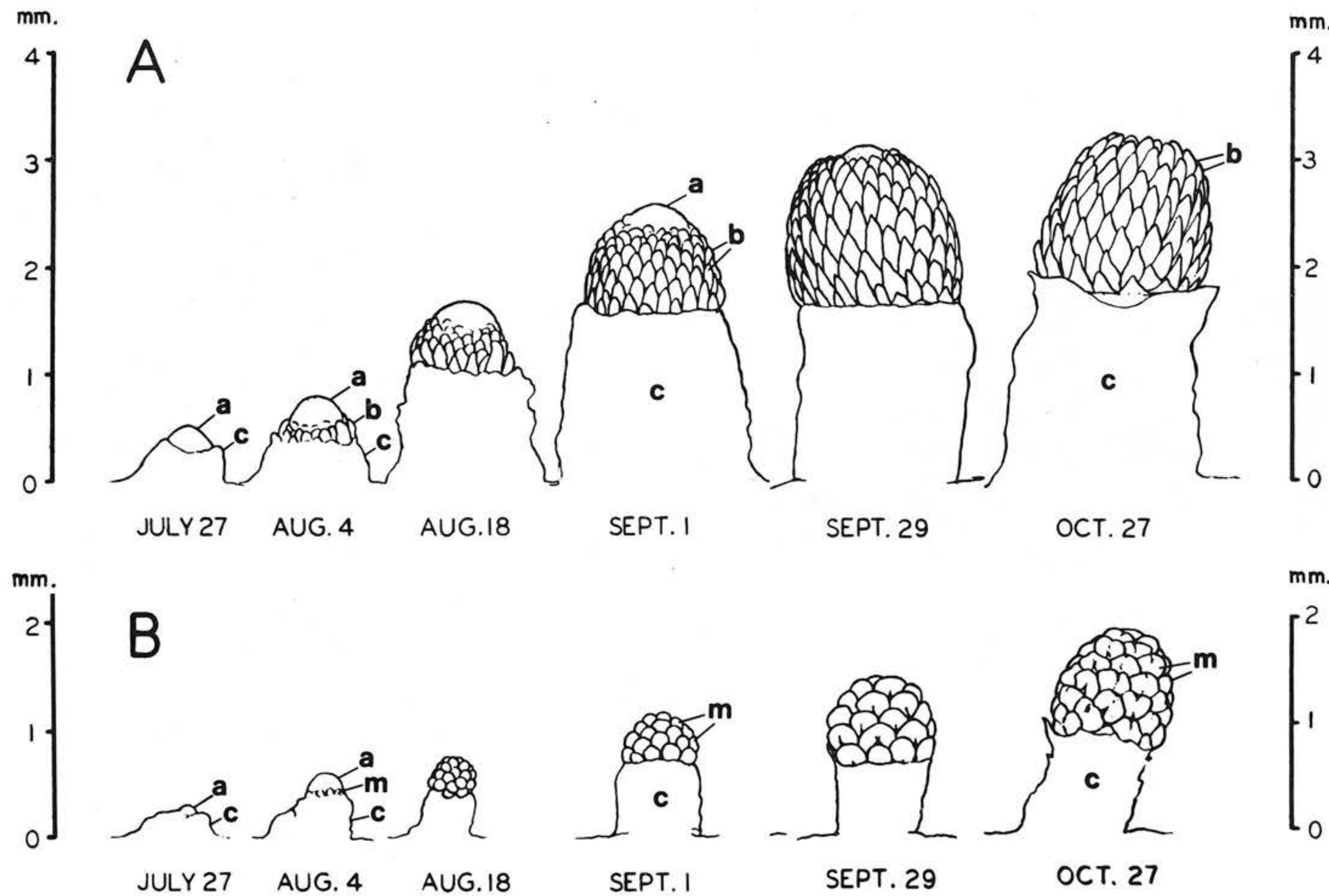

Figure 5.5. Developmental stages during flower-bud differentiation, tree 147, 1967: (A) megasporangiate bud; (B) microsporangiate bud; zero points represent the level of the shoot surface; strobilus apex (a), bract (b), cataphyll-bearing portion of axis (c), microsporophyll (m).

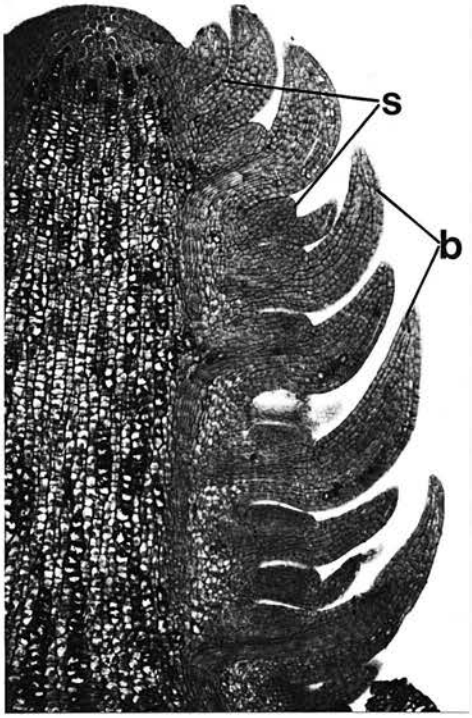

Figure 5.6. Median longisection through a megasporangiate strobilus showing ovuliferous-scale primordia (s) in the axils of all bracts (b) except the uppermost, October 17, 1967, x 110.

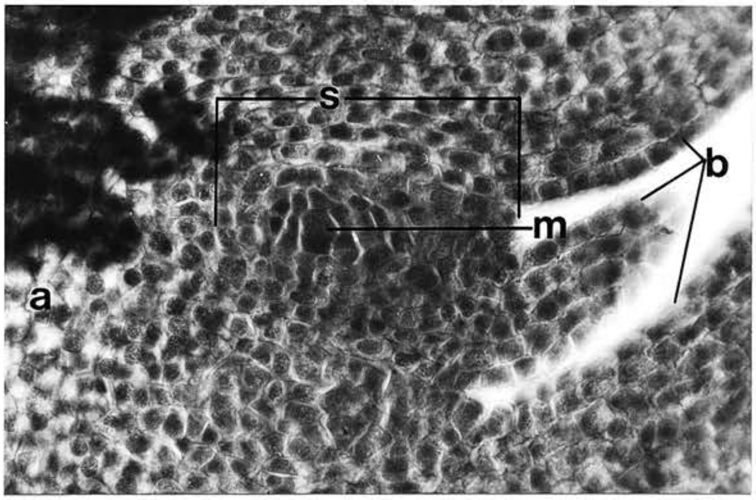

Figure 5.7. Longisection through a lateral portion of an ovuliferous scale (s) showing a possible megaspore mother cell (m), October 27, 1967: axis (a), bract (b), x 450.

arrangement of darkly staining cells around a single larger cell has been observed (Fig. 5.7). It seems likely that this was a megaspore mother cell since its position corresponds to that evident by early April (Powell, 1970 (Appendix 16, Fig. 3)). The timing of the appearance of the megaspore mother cell is being investigated further.

Examples of the kinds of lateral buds produced in the female zone are shown in Fig. 5.8. It is clear that megasporangiate buds are much larger than vegetative buds on comparable shoots. They also have a distinctive shape. They broaden very rapidly from the base to become generally as broad as (or broader than) the shoot on which they occur. Maximum bud diameter occurs in the central region, above which the bud narrows to a more or less obtuse apex (Fig. 5.8 A, B). Vegetative buds on the other hand, are more conical in general shape, and have a rounded apex (Fig. 5.8 B, C). The buds which fail to develop further than the cataphyllary stage in the year of origin (Fig. 5.8 B, C, D) are small and are clearly distinguishable, from late August on, from buds which develop further. When two female buds are produced on a shoot, the more distally situated bud is generally smaller at all stages of development than the more proximally situated one.

In 1968 and 1969 attempts were made to force development of buds which developed no further than the cataphyllary stage in their year of origin. In 1968 all developed buds (terminal, subterminal, lateral vegetative and female) were removed from shoots in the female zones of three trees in early April.[1]

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[1] Access to the female zones was achieved by means of a Hotstik 55-foot double-boom hydraulic extension (Pitman Manufacturing Company, Ontario), mounted on a two-ton, short-base truck. This equipment was loaned from the Maritime Regional Laboratory, Canada Department of Fisheries and Forestry, Fredericton, N. B.

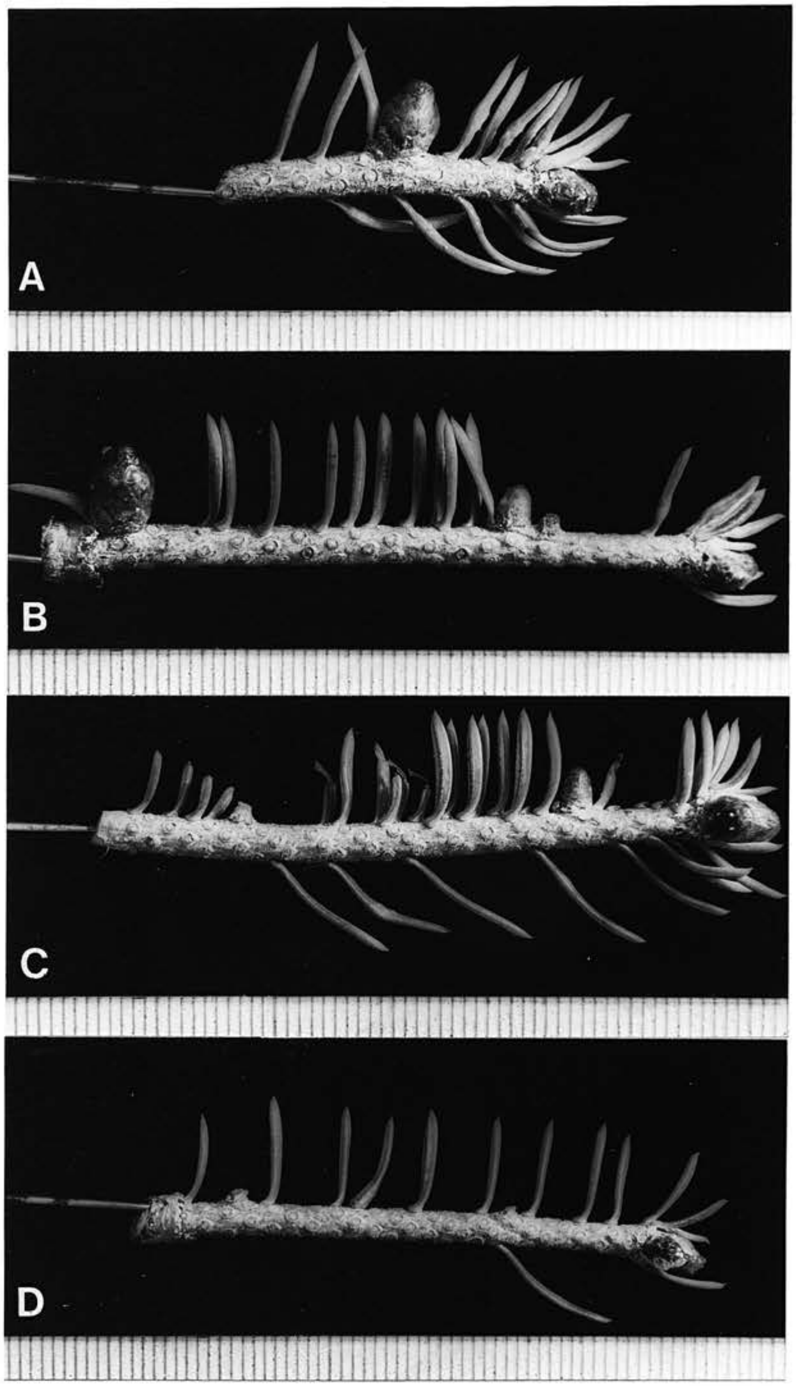

Figure 5.8. Types of over-wintering upper lateral buds produced in the female zone, tree 1, 1969: (A) megasporangiate bud, (B) left to right, megasporangiate, vegetative and latent buds, (C) left to right, latent and vegetative bud, (D) latent buds. Most needles have been removed from the shoots. Scales are in mm.

The undeveloped buds remaining were classified as relatively small or large. The effects of this forcing treatment were assessed in late October. The results are summarized in Table 5.1. It is evident that the non-developed buds are latent since the majority of both small and large undeveloped buds showed some development during the growing season. In no cases were additional (adventitious) buds formed. On two of the trees some latent buds on two-year-old wood developed. These are not included in Table 5.1.

TABLE 5.1. EFFECTS OF FORCING OF LATERAL BUDS

Tree	No. undeveloped buds April 8-9		Bud development October 24 (Nos.)			
			Undeveloped		Vegetative	Apparently female
	Small	Large	Small	Large		
502	103		17	9	35	42
		16			1	15
503	38		8	3	7	20
		15		1	2	12
507	29		12	2	7	8
		47		29	1	17

It should be noted that on each tree some buds remained latent, but within this category, some development did occur since some buds passed from the small to the large category. Table 5.1 shows that a large number of buds became apparently female. This terminology is used since all of the buds which were collected as female (13) were found on dissection, or on sectioning, to be vegetative. Thus, despite development to the normal female bud size and shape, the contents were not reproductive in nature. It should be noted that many additional buds developed the normal vegetative size and form. It should also be stressed that during the course of this study only in rare instances have vegetative buds on the 13 sample trees been erroneously classified as female. It seems, then, that under normal circumstances, female buds can be classified as such by position, size and shape alone, but under forced conditions the external appearance of the bud is not necessarily associated with its internal status.

A longitudinal section through a bud from tree 503, which was originally classified as female but which proved to be vegetative is shown in Fig. 5.9. The bud can be seen to have the general shape of a normal female bud except that the basal constriction is exaggerated because, in development in the second year, the small scales of the first year have been pushed aside. The new portion of the bud, including surrounding scales, has been formed above at least the outer scales

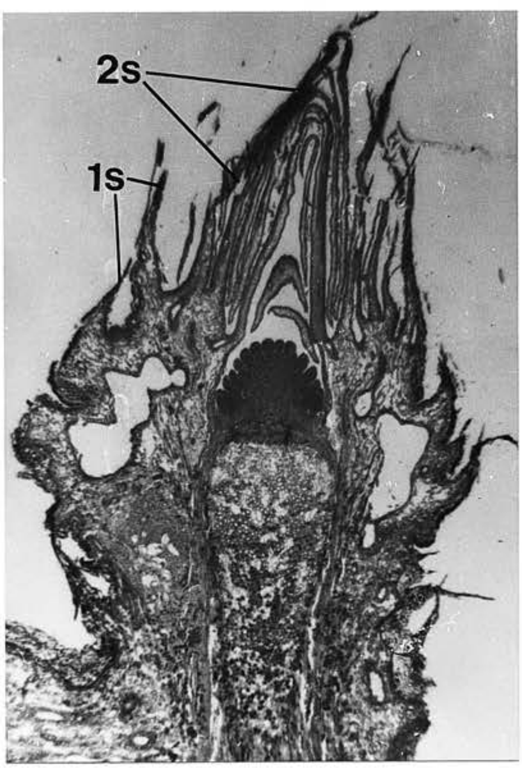

Figure 5.9. Median longisection through an upper lateral bud which developed in the second year from a latent first-year bud, tree 503, October 24, 1968; first-year scales (1s), second-year scales (2s), x 22.5.

of the latent bud. The new portion of the bud, however, is essentially conical: it is only when new and old are considered together that the bud assumes the general female shape.

In order to test some of the findings of 1968, individual shoots which bore latent buds were decapitated in the early spring on four trees which could be reached from the towers. A selection of the buds developed by the end of October is shown in Fig. 5.10. Figure 5.10 E and G are examples of naturally induced latent bud development which resulted from the killing of new shoots by the spruce budworm. Buds developed on each of the eight shoots in Fig. 5.10 exhibit female-bud characteristics when considered as a whole. This is particularly true of the right-hand bud in C and of each of the buds in D, E and F. The buds in A and B are somewhat smaller, but are still large enough to be considered female when size relative to shoot diameter is considered. The central bud of G and the right-hand bud of H are similar, while the smaller buds in G and H and C are more vegetative in appearance. In these instances, the fact of delayed development has caused the basal parts of the buds to be narrower than normal in a vegetative bud. Thus, on these shoots many of the buds which developed from latent buds on two-year-old or one-year-old wood were apparently female. However, dissection of each of these buds, and others which were similar in appearance, revealed all to be vegetative.

It seems, therefore, that while the possibility remains that latent buds can develop reproductively (only 13 of the 114 apparently female buds developed in 1968 were dissected or sectioned, but observations using binoculars from the ground showed that no cones formed on the treated branches in 1969), the evidence is strong that latent buds in the female zone develop vegetatively only.

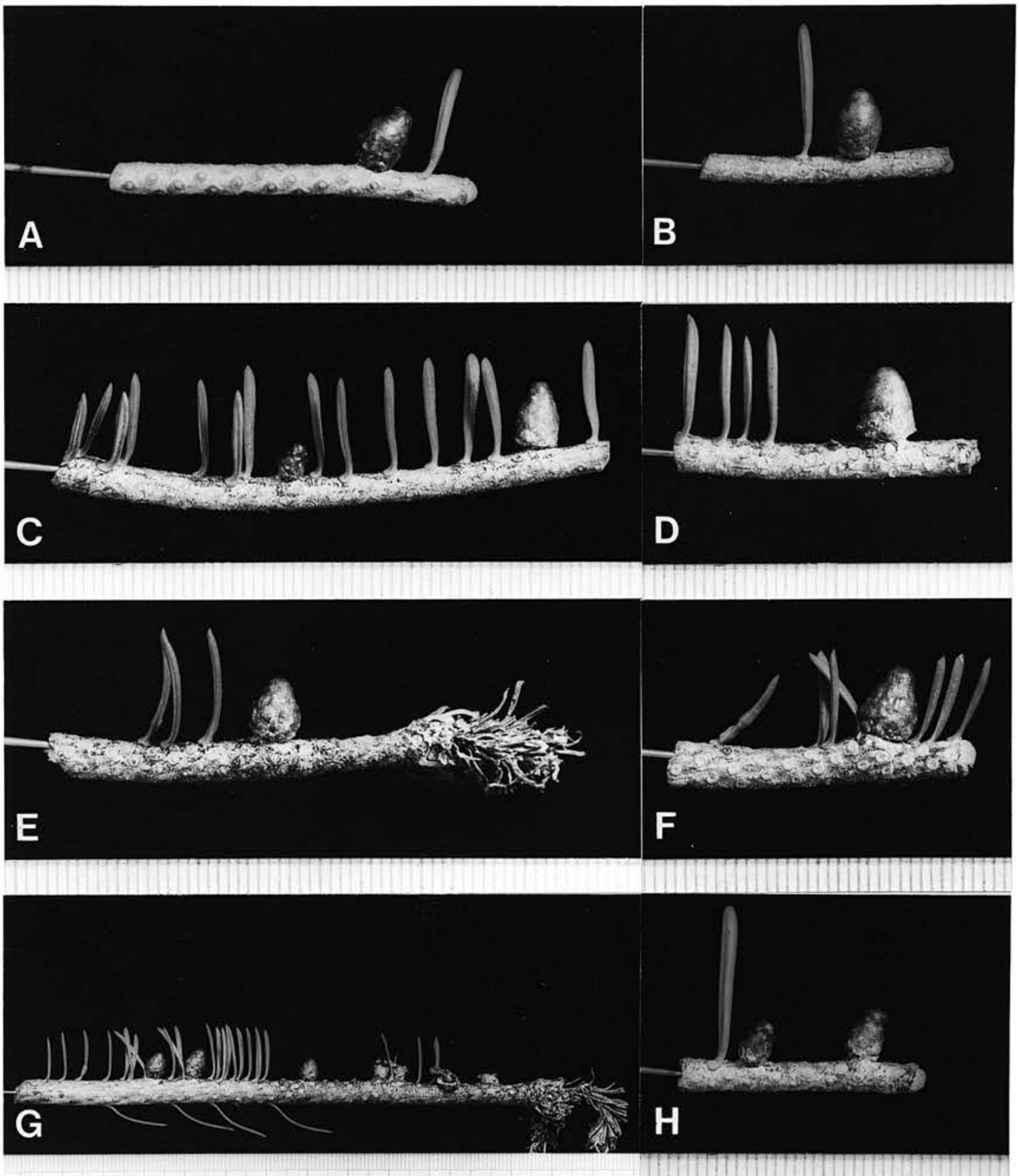

Figure 5.10. Upper lateral buds forced to develop from latent buds in their second or third year as a result of shoot decapitation (A-D, F, H) or of killing of the new shoot by spruce budworm (E,G), 1969: (A, B, D) on two-year-old shoots, tree 13, (C,H) on one-year-old shoots, tree 324, (E,F) on one-year-old shoots, tree 144. Most needles have been removed from the shoots; scales are in mm.

ii. On shoots in the male zone

A few of the more vigorous leading shoots in the male zone bear vegetative buds or latent buds on their upper sides in a manner similar to shoots in the female zone. In the vast majority of cases, however, lateral buds on male-zone shoots are borne on the lower sides of the shoots only. These buds which are potentially microsporangiate, are thus clearly distinguishable, by position alone, from the female or vegetative buds of the female zone.

The initiation of lateral-bud primordia on the lower sides of shoots in the male zone is similar to that of lateral buds on shoots in the female zone. However, the primordia are smaller, being about half of the size of female-zone primordia (Fig. 5.11). The material examined indicates that the primordia occur at about the same time in both zones, though development in the male zone appears to be a little slower. The primordia occur in the axils of many needles on the lower side of the shoot, and all are initiated at about the same time. Prophyll initiation occurs at about the time of bud bursting and cataphyll production continues, as in the female zone until mid July.

The primordia may be distinguished, as minute, smooth structures amid the hairs on shoots from which needles have been removed, one or two weeks after bud bursting. In some years many shoots bear no primordia, or very few, and thus several shoots may have to be examined before primordia are found. As they develop, and as the outer scales become progressively deeper brown in colour, the buds become much easier to see.

Drawings of the later internal developmental stages are shown in Fig. 5.5 B. Initiation of microsporophyll primordia starts in late July and proceeds rapidly. By late August, sections have shown that microsporophyll

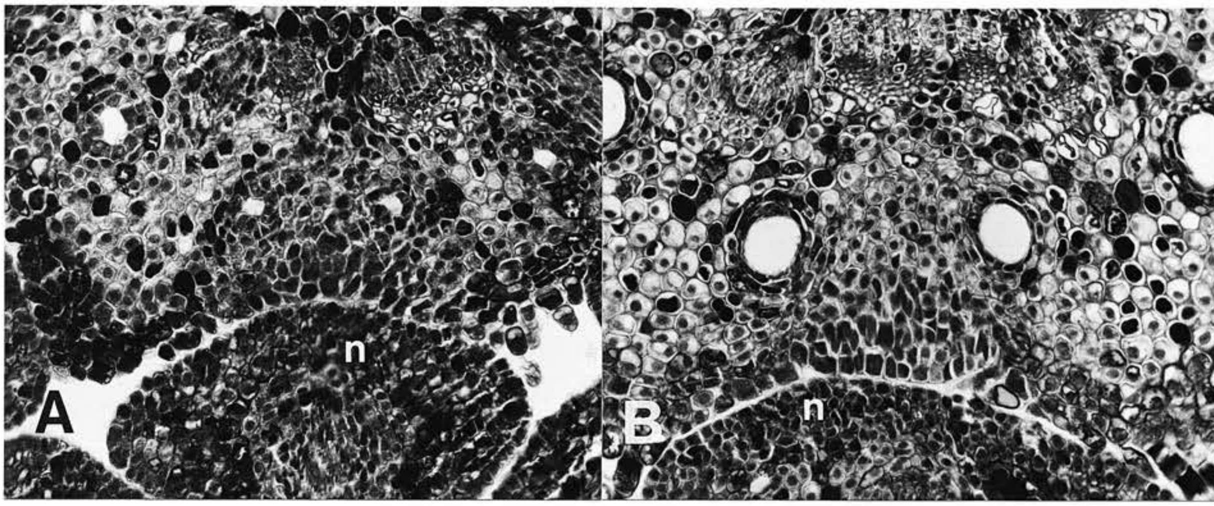

Figure 5.11. Initiation of lower lateral buds: (A) bud primordium in the cortex of the shoot, tree 13, 13 May 1969; (B) bud primordium more clearly developed, but without prophylls, tree 324, 21 May 1969; both x 225, needle (n).

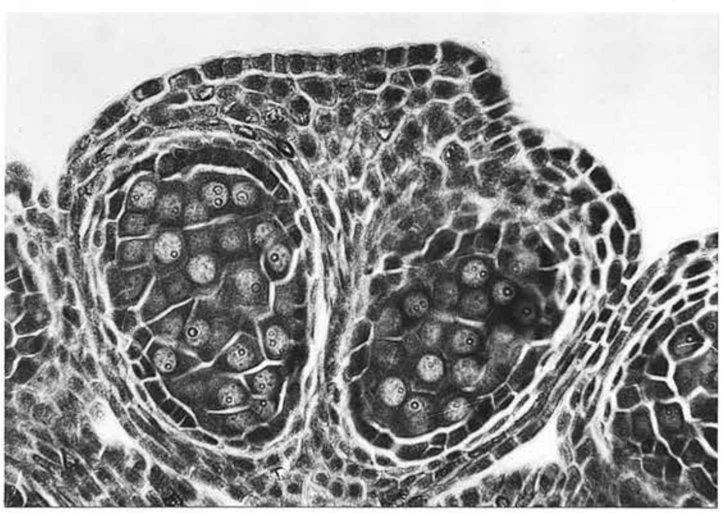

Figure 5.12. Median longisection through an apically situated microsporophyll showing two microsporangia and sporogenous cells inside well developed tapetal layers, October 6, 1967, x 375.

primordia cover the entire surface of the developing strobilus; no apical meristem can be distinguished although small areas of flattened tissue exist between the bases of the microsporophylls produced in the apical regions. During late August or early September a crown develops across the axis just below the developing strobilus. In early September, areas of relatively large cells become evident in the tissues of the microsporophylls. These areas of organization develop rapidly as the microsporophylls become noticeably bi-lobed (Fig. 5.5 B, Sept. 29). By early October (Fig. 5.12) sporogenous cells and a tapetal layer are evident in each of the lobes (microsporangia) of each microsporophyll. As was the case with megasporangiate buds, as the microsporangiate strobilus enlarges, so too does the cataphyll-bearing axis beneath the strobilus. Bud measurements on several trees have shown that both microsporangiate and megasporangiate buds cease their overall growth during October. Powell (1970) has indicated that there are no significant changes in overall bud size between late October and March.

Shoots in the male zones of several trees have been observed to bear microsporangiate buds on their upper sides as well as in the more normal underside positions. Such buds are, however, restricted to the extreme basal portions of the shoots. On some shoots normal microsporangiate buds develop at the bases of the shoots in positions distal to brown, dry structures intermediate between bud scales and needles.

As in the case of lateral buds on female-zone shoots, lateral buds on male-zone shoots may fail to develop further than the cataphyllary stage: some cease development after production of only a few cataphylls. Failure to complete development is common for the buds initiated on the upper distal portions of those few shoots which bear them. Buds which complete development in their year of origin in such positions are usually vegetative. Frequently all the potentially microsporangiate buds on a shoot fail to develop. Fully formed and non-developed buds are shown in Fig. 5.13.

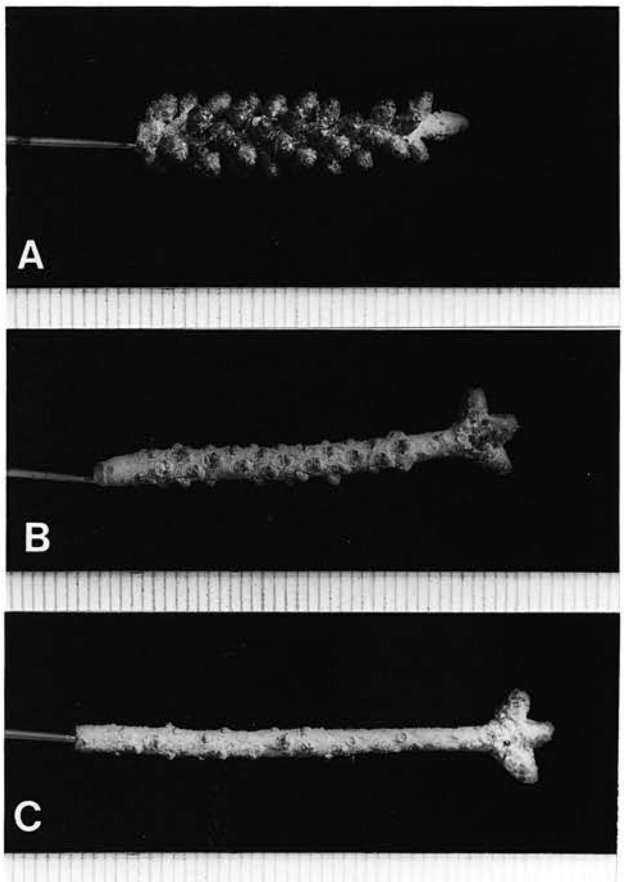

Figure 5.13. Types of over-wintering lower lateral buds produced in the male zone, tree 1, 1969: (A) microsporangiate buds, (B) latent buds which ceased development in the late cataphyll-producing stage, (C) latent buds which ceased development in the early cataphyll-producing stage. Views are of the undersides of the shoots, from which all needles have been removed. Scales are in mm.

A limited amount of forcing of latent-bud development has been tried in the male zones of trees reached from the towers. Some results are shown in Fig. 5.14. In each case, the buds formed from latent buds in distal positions are

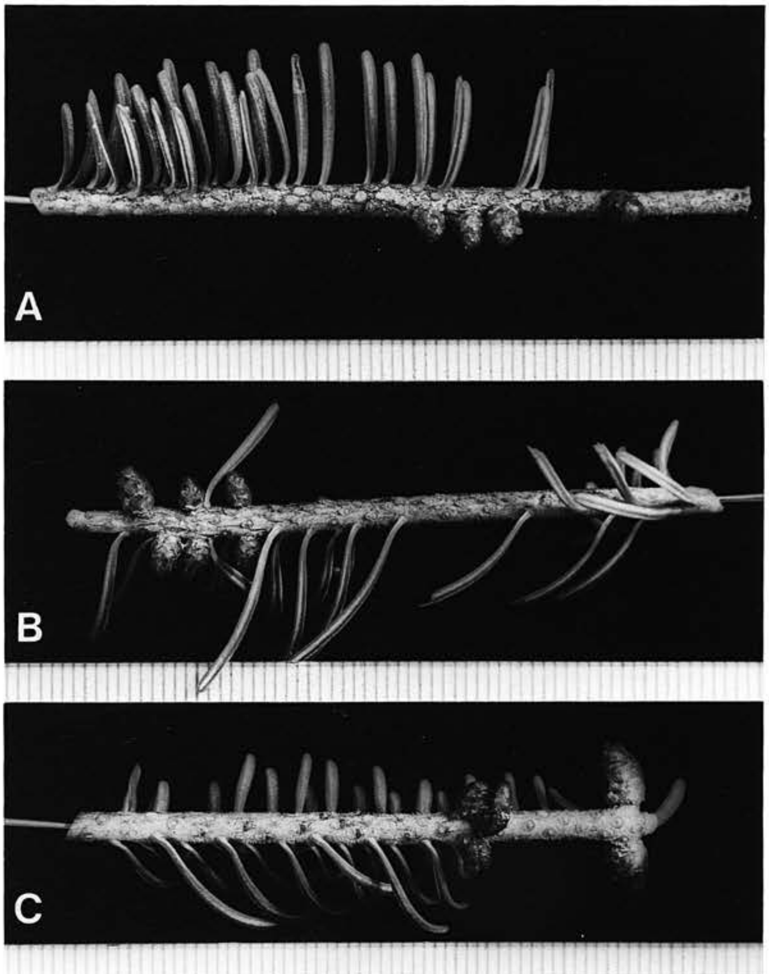

Figure 5.14. Lower lateral buds forced to develop from latent buds in their second year as a result of shoot decapitation, 1969: (A) side view of shoot, tree 144, (B) underside of shoot, tree 144, (C) underside of shoot, tree 13. Many needles have been removed from each shoot. Scales are in mm.

larger than others in more proximal positions. Many of the latter appear to be normal microsporangiate buds, but all buds examined have proved to be vegetative. It appears that growth is promoted in more distally situated buds to a greater extent than in those further back on the shoot. This would seem to be a response to the lack of an apical growing point on the shoot and thus determined by auxin gradients. It is possible that a similar response occurs in decapitated shoots in the female zone. In those cases in Fig. 5.10 in which two buds occur on the shoot and one is close to the decapitation point, that bud has shown the greater development.

C. Development of Buds in Atypical Positions

During the course of this study some microsporangiate and megasporangiate strobili have been observed in atypical positions. These indicate that buds initiated in any position may have the capacity to develop into vegetative, male or female buds. However, vegetative buds have not been observed to develop in their year of origin in typically male positions, nor have female buds been observed in male positions.

In 1966 on tree 3, a female cone was developed from a bud in the subterminal position on a vigorous shoot in the first internode. The only other unusual female occurrence was on tree 9 in the same year when a cone was produced in a normal female position on a shoot well within the male zone. This cone was situated on a main-whorl branch three whorls below any other female occurrence.

On tree 5 in 1966, a male strobilus developed from a subterminal bud on a first-order side shoot of a branch in internode II. On the same shoot a large, upright male strobilus developed from a bud which had been classified as female (Fig. 5.15 A). Other shoots on the same branch produced normal female strobili. Similar upright male strobili were produced from apparently female buds on four shoots on other branches in the same internode. Somewhat smaller, but again, upright male strobili developed from three buds on the upper sides of shoots in internode III and whorl IV. In these cases the buds had been considered

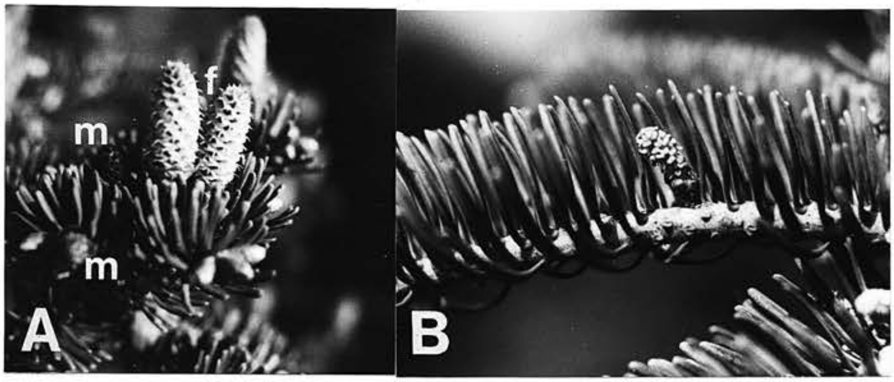

Figure 5.15. Male strobili in atypical positions: (A) male (m) strobili in female and subterminal positions, tree 5, 1966, female strobilus (f) x 0.8; (B) male strobilus in upper lateral position, tree 7, 1968, x 1.0.

vegetative. All these male occurrences were within the normal female zone. Two male strobili also developed from apparently vegetative buds on the upper sides of two main-whorl leading shoots in the upper part of the male zone (whorl VI) of tree 7 in 1968 (Fig. 5.15 B).

D. Effect of Loss of the Leading Shoot on the Nature of Buds Developed

Several references have been made to the fact that the leading shoots were broken from trees 5 and 9 during the latter part of the 1964 growing season. The subsequent development of the apical portions of the crowns of these trees provides an interesting contrast. In both trees the leading shoot was broken at its base leaving four 1964-whorl branches at the apex of the tree. These branches formed whorl II in the 1966 seed year and whorl IV in 1968 (Appendices 5 and 7). In both years, this whorl bore cones, but in 1968 it was the only bearing whorl on each tree. Upper branches in the 1964 internode also bore a few cones (Tables 4.10 and 4.11).

The uppermost male-strobilus occurrences in 1964, 1966 and 1968 were, for tree 5, in internode 1961, internode 1963 and internode 1964, and for tree 9, in internode 1959, internode 1962 and internode 1964 (from Table 4.8). These data show that there was a normal rise in the upper level of the male zone: in each tree the zone reached the 1964 internode in 1968.

By 1967, however, the upper crowns of the two trees were strikingly different (Fig. 5.16). In 1965, three of the new terminal shoots on the 1964-whorl branches of tree 5 turned upwards and by 1967 one of these had become dominant and thus had become the new leading shoot on the tree (Fig. 5.16 A). In 1969, definite whorl branches were formed on this leading shoot and 139 female buds were developed well above the normal level of the 1964 whorl. (The 1964-whorl branch which remained horizontal bore male buds only, as did lower shoots on the upturned branches.) Thus, although female-cone bearing was much reduced in 1968, the capacity for increased bearing in subsequent years is great.

On tree 9, the 1965 terminal shoots did not turn upwards and horizontal growth only has occurred in each subsequent year. The result is that tree 9 became flat-topped with no tendency for any branch to assume apical dominance (Fig. 5.16 B). In 1969, most shoots on the 1964-whorl branches developed male buds. In consequence, the apical region of the tree became entirely male with no vigorous vegetative shoots and with no capacity to form female buds.

This indicates that the change from a capacity to form female buds to one to form male buds is related to branch age and shoot vigour. Each branch appears to be capable of forming female buds for five or six years, after which male buds are formed. Where main-branch-terminal shoots remain vigorous, they may retain the capacity to produce lateral buds on their upper sides. If these

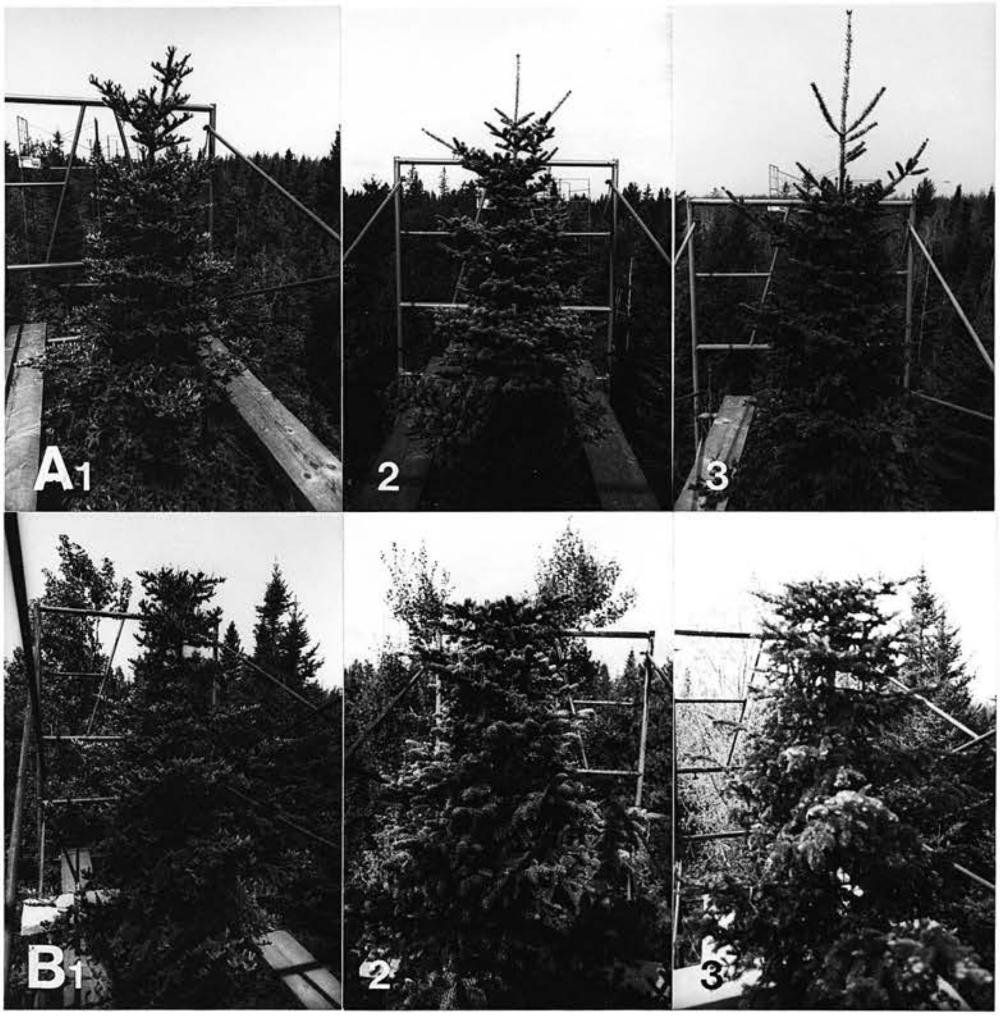

Figure 5.16. Development of the upper crowns of trees 5 (A) and 9 (B) following the loss of their leading shoots in August 1964: (1) 13 June 1967, (2) 5 August 1967, (3) 26 April 1969.

buds develop, they are normally vegetative. Vigorous shoots of this kind rarely produce male buds (cf. Morris, 1951). If such a branch eventually increases in vigour and turns upwards to assume dominance, the main side branches produced upon it will gain the capacity to produce female buds. It seems, therefore, that a continued capacity to carry female buds is contingent upon the maintenance of apical dominance or re-establishment of apical dominance if this is lost.

E. Numbers and Positions of Lateral Buds on Shoots in the Female Zone

The numbers of lateral buds initiated on shoots in the female zone depend on the vigour of the shoots. Whorl-branch terminal shoots typically carry more buds than shoots further back on the branches. Many short shoots carry no buds. Table 5.2 shows the mean lengths of shoots bearing different numbers of buds and indicates very clearly that the number of buds is positively related to shoot length.

TABLE 5.2. MEAN SHOOT LENGTHS (CM) OF SHOOTS BEARING DIFFERENT NUMBERS OF LATERAL BUDS ON TREES 3, 8 AND 11 IN EACH OF SIX YEARS

Tree	Year	0	1	2	3	4	5	6	7+[1]	No. whorls Included
3	1963	0.9	3.4	5.0	8.2	10.5	-	-	-	2
	1964	2.8	4.2	6.8	-	-	-	-	-	3
	1965	2.4	2.9	5.3	9.0	9.8	-	-	-	4
	1966	2.4	4.1	4.6	6.8	8.6	-	-	-	5
	1967	1.5	2.3	4.0	5.5	-	-	-	-	5
	1968	3.0	4.1	5.3	8.3	-	-	-	-	5
8	1963	2.3	2.4	4.8	4.9	6.4	-	-	-	2
	1964	2.0	3.0	5.7	7.6	-	-	-	-	3
	1965	1.8	2.5	4.7	-	-	-	-	-	4
	1966	1.5	2.0	3.3	3.1	-	-	-	-	5
	1967	1.9	1.9	3.1	5.2	4.1	-	-	-	5
	1968	1.9	2.7	4.2	-	-	-	-	-	5
11	1963	2.9	3.6	5.4	8.7	9.5	13.3	15.0	15.9	2
	1964	2.6	4.8	6.5	-	14.3	14.7	-	15.9	3
	1965	2.3	3.0	4.8	7.7	11.8	10.8	13.2	14.1	4
	1966	1.7	3.1	4.0	5.2	6.0	6.5	-	-	4
	1967	1.7	2.8	4.1	6.4	-	-	-	-	4
	1968	2.1	2.6	4.1	8.7	9.6	11.6	15.3	15.8	4

[1] Maximum number recorded, 11

TABLE 5.3. PERCENTAGES OF SHOOTS BEARING DIFFERENT NUMBERS OF LATERAL BUDS IN THE UPPER FOUR WHORLS OF THREE TREES IN EACH OF FOUR YEARS

Tree	Year	No. of shoots[1]	Number of buds on shoots					
			0	1	2	3	4	5+[2]
3	1965	170	21.2	52.9	22.9	2.3	0.6	0
	1966	134	67.2	7.5	17.2	5.1	3.0	0
	1967	121	43.0	34.7	21.5	0.8	0	0
	1968	91	58.2	31.2	9.9	0	0	0
8	1965	93	47.3	36.5	16.2	0	0	0
	1966	70	68.6	25.7	4.3	1.4	0	0
	1967	55	29.8	47.4	14.0	3.5	1.8	0
	1968	43	81.4	9.3	9.3	0	0	0
11	1965	467	58.4	16.5	19.7	2.6	0.4	2.4
	1966	422	87.8	4.7	5.2	0.9	0.9	0.2
	1967	339	54.8	25.5	17.3	2.4	0	0
	1968	306	42.2	25.5	28.1	1.6	1.3	1.6

[1] Shoots which completed development: owing to a small amount of breakage, the numbers do not necessarily indicate the total shoot production.

[2] Maximum number recorded, 11

Since it is only the more vigorous shoots which bear relatively large numbers of buds, the majority of shoots bear zero, one or two buds (Table 5.3). The positions of buds along two-budded shoots has been observed to be strikingly uniform on all trees. Measurements on trees 3, 8 and 11 provided the data on this point in Table 5.4. Although there is some variation from year to year in each tree, it is clear that the proximal bud occurs at about 30 per cent and the distal bud at about 75 per cent of the distance along the shoot. There is some indication in Table 5.4 that the first bud occurs further along the shoot in a heavy cone-bearing year (1966). However, the quantity of data is not sufficient to provide proof on this point. Buds on single-budded shoots tend to occupy positions corresponding with either of those on two-budded shoots, although the proximal position is the commoner. Of the 628 single-budded shoots used in calculations

TABLE 5.4. MEAN PERCENTAGE POSITIONS OF BUDS ALONG TWO-BUDDED SHOOTS IN THE FEMALE ZONES OF THREE TREES

	Tree 3					Tree 8					Tree 11				
	No.	Bud 1		Bud 2		No.	Bud 1		Bud 2		No.	Bud 1		Bud 2	
Year	Shoots	Mean	S.E.	Mean	S.E.	Shoots	Mean	S.E.	Mean	S.E.	Shoots	Mean	S.E.	Mean	S.E.
1963	9	15.9	1.5	71.1	1.5	10	25.8	1.6	76.4	1.2	17	28.7	1.5	80.4	2.2
1964	16	28.8	1.2	70.5	1.0	5	10.7	3.3	74.1	2.3	32	28.5	0.8	74.0	1.3
1965	39	28.2	1.1	75.7	0.9	15	34.2	1.8	78.9	1.7	92	27.4	0.7	74.1	1.1
1966	26	34.0	1.2	72.9	1.6	3	44.3	5.2	82.0	2.8	22	40.0	1.7	80.3	1.0
1967	32	28.1	1.1	73.6	2.6	8	27.0	1.8	75.8	3.2	59	30.4	1.0	75.6	1.5
1968	16	28.0	1.4	72.2	1.8	4	43.9	5.9	79.6	5.3	86	31.0	0.8	77.6	0.7
Mean	138	28.5	0.6	73.4	0.8	45	32.2	1.3	77.5	1.0	308	30.1	0.4	76.2	0.6

for Table 5.2, 85 per cent bore buds at about the 30-per-cent distance. These shoots had an average length about 0.9 cm shorter than those bearing buds singly at about the 75-per-cent distance. The proportion of distally bearing, single-budded shoots tended to increase in cone-bearing years.

On three-budded shoots, the first bud is again found most commonly at about the 30-per-cent-distance point. The second and third buds, however, tend to be situated fairly close together at about 64 and 82 per cent of the distance along the shoot respectively. With four or more buds, the spread of buds along the shoot becomes more uniform, though tending to be more concentrated at the distal end.

5.2 NUMBERS OF SHOOTS AND BUDS PRODUCED IN THE FEMALE ZONE IN FLOWERING AND NON-FLOWERING YEARS

A. Numbers of Shoots Produced in the Female Zone

In the literature review it was stated that Morris (1951) found a reduction in numbers of shoots formed in a flowering year. However, Morris gave no indication of the types of shoots affected. The character of the shoots in the female zone was described in Section 4.1 B, particularly in relation to Figs. 4.10 and 4.11. The shoots may be classified as terminal, subterminal (at either side or above or below the shoot, at the base of the terminal shoot, and thus, alternatively called nodal) or as lateral (intermediate shoots, between the nodal points). In the previous section it was shown that the greatest variation in character is found among the lateral buds. It is therefore likely that numbers of lateral shoots are affected more than are numbers of terminal and subterminal shoots. Further, numbers of lateral shoots may be affected directly by replacement with female structures, whereas terminal and subterminal shoots, if affected, will be indirectly affected as a rule. These aspects will be dealt with in this section.

At the outset, it must be pointed out that the potential number of shoots within the female zone fluctuates widely. This fluctuation depends, initially, upon the numbers of whorl and internode branches produced in each of the previous four or five years. A notable reduction in numbers of internode branches produced in years since 1964 has already been mentioned (Table 4.4). This is shown in a different form, together with data for whorls, in Table 5.5.

TABLE 5.5. MEAN NUMBERS OF MAIN BRANCHES PRODUCED ON EIGHT TREES FROM 1960 TO 1968

	Year								
	1960	1961	1962	1963	1964	1965	1966	1967	1968
Whorl Branches									
Means	3.9	3.9	3.4	3.8	3.5	2.5	2.9	3.1	2.8
4-year accumulation				15.0	14.6	13.2	12.7	12.0	11.3
Internode Branches									
Means	15.5	15.0	15.4	13.2	11.8	9.0	5.5	6.6	5.8
4-year accumulation				59.1	55.4	49.4	39.5	32.9	26.9

When the means for individual years are totalled, it is evident that female-zone-branch production has declined steadily throughout the period of the study. (See also, data on numbers of shoots in Tables 5.3 and 5.11 and in Appendix 15.) This means that comparisons of absolute branch or shoot numbers in flowering and non-flowering years are meaningless except in a general way. Numbers are possibly affected by ageing of the trees and by the character of the growing seasons as well as factors such as flowering and shoot breakage.[1] Thus some means must be found of comparing shoot numbers on a relative scale. Control trees (non-flowering

[1] As has been indicated previously, handling, and the presence of the towers, have resulted in some shoot breakage. Where this has been of significant extent, trees on which it has occurred have been omitted from analyses. However, it is recognized that loss of any shoot may have a negative cumulative effect on subsequent shoot production.

trees in a flowering year) would serve this purpose. However, for the age and size of trees used in this study, suitable trees have not been available, and the information provided in Chapter 3 indicates that naturally occurring non-flowering mature trees would be extremely difficult to find. It is possible that the effects of cone-bearing may be shown on individual branches or shoots within the female zone. If this is so then this may provide a means of comparison in judging the effects of cone bearing on shoot production.

Complete data on numbers of shoots produced are available for 1967 and 1968 for eight trees with undamaged female zones.[1] Similar data are available for four of these trees for 1969. Comparisons between numbers of shoots produced in 1967 and 1968 and in 1968 and 1969 were made for shoots of different order by whorl. Thus for each year of each pair of years, the numbers of shoots of order 7 and 8 produced in whorl I, whorl II and whorl III on shoots of order 8 of the previous year on each tree provided three sets of data for a paired comparison. Numbers of order 6 shoots produced in whorl II and whorl III on shoots of order 7 of the previous year, and numbers of order 5 shoots produced in whorl III on shoots of order 6 of the previous year provided more sets of data. A similar breakdown of numbers of shoots produced was obtained for internodes I, II and III. In this manner, 96 pairs of comparable data were obtained for 1967-68 and 48 for 1968-69 (Appendix 13). Each pair of data was then classified according to whether the subtending shoots for the 1968 shoots carried many cones, a few cones or no cones. A series of paired analyses were then performed on each class of shoots.

The results of the 1967-68 paired comparisons (Table 5.6) show that very significantly more terminal (and subterminal) and lateral shoots combined were

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[1] A small amount of shoot breakage occurred on some of these trees but this was taken into account in calculating numbers of shoots produced.

TABLE 5.6. ANALYSIS OF PAIRED DIFFERENCES IN NUMBERS OF SHOOTS PRODUCED PER SHOOT OF HIGHER ORDER IN THE UPPER THREE WHORLS AND INTERNODES FOR 1967-68 AND 1968-69

Type of shoot produced	Year	Shoot category (1968 cone bearing)								
		Many cones			Few cones			No cones		
		Mean	t	df	Mean	t	df	Mean	t	df
Terminal[1] & lateral	1967	4.23	6.30**	33	2.75	2.16*	27	2.26	-3.89**	33
	1968	3.02			2.47			2.67		
Terminal	1967	2.93	1.80	33	2.33	1.67	27	1.85	-4.79**	33
	1968	2.78			2.19			2.21		
Lateral	1967	1.30	5.47**	33	0.42	2.39*	27	0.41	-0.60	33
	1968	0.36			0.28			0.45		
Terminal & lateral	1968	3.13	-4.21**	20	2.47	-0.86	14	1.84	2.21*	11
	1969	3.78			2.63			1.61		
Terminal	1968	2.77	0.62	20	2.28	0.19	14	1.78	2.31*	11
	1969	2.71			2.28			1.57		
Lateral	1968	0.35	-4.05**	20	0.27	-1.20	14	0.06	-0.32	11
	1969	1.06			0.42			0.07		

1 Subterminal shoots included with terminal shoots.

produced in 1967 on non-cone-bearing shoots than on comparable 1968 shoots that bore many cones. When fewer cones were borne, the differences between the means was less clear, but still significant. When comparable shoots which bore no cones in either years were compared, very significantly more shoots were borne in 1968. Thus it appears that the conditions in 1968 favoured development of more shoots than on comparable shoots in 1967. However, this was completely reversed when cones were borne. The analyses of 1968-69 data gave similar results (Table 5.6), but here, when cones were not a factor, the 1968 shoot numbers were greater than those for 1969. It is clear that the presence of cones reduces the number of shoots produced.

The paired analyses were repeated for terminal shoots and lateral shoots separately. In Table 5.6 there is clear evidence that the number of lateral shoots produced is much reduced in a cone-bearing year. With many cones present, the differences are very significant: with few cones present a significant difference exists between 1967 and 1968, but with the smaller 1968-69 sample, the difference between the means, though of similar order, is not significant. In neither comparison is the difference between non-cone-bearing means significant. Significant differences were found, however, between non-cone-bearing means for terminal shoots. These results indicate that more terminal shoots were produced in 1968 than in either of the other years. Though not significantly different, the terminal shoot means when cones were present, showed a reverse tendency for the 1967-68 comparison and close similarity for the 1968-69 comparison. If the percentage differences between the means for no cones were applied to those for many and few cones so as to provide expected values for 1968, then a very clear reduction in terminal shoot numbers would be apparent. It can thus be concluded that both the numbers of terminal shoots and the numbers of lateral shoots are reduced in a flowering year. This reduction is very clear in the case of lateral shoots, but is much less apparent among terminal shoots, and, in fact may only show when proportional comparisons involving non-cone-bearing shoots are used.

B. Numbers of Buds Produced in the Female Zone

Examination of the individual mean values for terminal buds (Appendix 13) shows that on vigorous shoots more than three terminal buds (terminal plus subterminal buds) form on individual shoots more commonly in a non-cone-bearing year than in a cone-bearing year. The extra buds are normally lower subterminal buds, very occasionally, upper subterminal buds. An exhaustive examination of terminal buds has not been made in this study and thus data are lacking on whether or not such buds are initiated but fail to develop. However, in no instance in the course of other observations on the trees or in terminal-bud measurements on each main branch has evidence of lower or upper subterminal bud failure been observed. On the other hand, failure of subterminal side buds to develop fully is relatively common (Fig. 5.2), though precise data on the occurrence of such buds are lacking.

Some data on "formed" terminal and subterminal buds are available for trees 3, 8 and 11 for which details on shoot development in the female zone have been obtained over a number of years. The percentages of terminal buds which were classified as formed in their year of origin, but which failed to open in the following year are given in Table 5.7. Each of the trees bore cones abundantly in 1966 (flower buds formed in 1965), but only trees 3 and 8 bore cones in 1968. These limited data are obviously inconsistent. A large proportion of

TABLE 5.7. PERCENTAGES OF TERMINAL BUDS FORMED WHICH FAILED TO DEVELOP SHOOTS IN THE FOLLOWING YEAR

Tree	Buds formed in year			
	1965	1966	1967	1968
3	4	12	2	25
8	23	8	10	10
11	25	3	6	no data

the terminal buds formed in 1965 on trees 8 and 11 failed to produce shoots in 1966, while on tree 3 a very small proportion of buds did not open. Tree 3 also shows a reverse tendency in the flowering years, 1966 and 1968: a far greater proportion of buds produced in these years failed to open in the following years than on trees 8 and 11. These data are too few to warrant the drawing of definite conclusions, but it does seem that there are tree-by-tree differences in the capacities of buds classified as formed to develop in cone-bearing and non-cone-bearing years. Decreases in the numbers of terminal shoots developed in cone-bearing years may result from failure of formed buds to develop,as well as from failure of bud initiation or cessation of development prior to needle primordial formation.

From the fact that the number of lateral shoots produced per shoot of higher order is reduced in a cone-bearing year, it is obvious that the number of vegetative buds formed per shoot will be less in a year in which female buds are also formed. It therefore seems likely that at least some female buds take the place of vegetative buds. However, the occurrence of latent lateral buds must be taken into consideration. Complete data on the distribution of all lateral buds (on the upper sides of the shoots) produced in the upper five whorls and four internodes are available for four undamaged trees for a three-year period, and for an additional four trees for two successive years.

The numbers of buds of different types which were formed per shoot in each year were grouped according to whorl or internode position (Appendix 14), and a series of paired comparisons between successive years were made. Eleven sets of seven or eight pairs of mean values were used for the 1967-1968 comparisons, and eleven sets of four pairs of mean values for the 1968-1969 comparisons. A t-test was performed on the between-year mean differences. The results are given in Table 5.8.

As is to be expected, fewer significant differences were found in the 1968-1969 comparisons, with only three degrees of freedom, than in the 1967-1968 comparisons, with six or seven degrees of freedom. However, both sets of data display a strikingly similar but reverse pattern with respect to sign. This indicates that conclusions can be drawn from these small-sample data with a reasonable degree of confidence. The leading-shoot data are an exception, being derived from pairs of actual bud numbers rather than pairs of mean bud numbers from several shoots on each tree.

In both comparisons more vegetative buds were borne on shoots in upper zone positions in 1968 than in the other years, the whorl I differences being significant. In lower zone positions fewer vegetative buds occurred in 1968. A similar, but stronger, trend is shown for latent buds with more differences being significant, and with generally greater differences. It is clear, for the upper zone positions, that when female buds are formed (1967 and 1969) both vegetative and latent buds produced per shoot are fewer. Since there are no significant differences between the numbers of lateral buds (total) in these positions (and the differences are smaller than in any other position), it is evident that female buds take the places of both vegetative and latent buds - or, more correctly,

TABLE 5.8. MEAN PAIRED DIFFERENCES BETWEEN MEAN NUMBERS OF LATERAL BUDS PER SHOOT AND BETWEEN PERCENTAGES OF NON-BUD-BEARING SHOOTS IN THE FEMALE ZONES OF SEVERAL TREES IN 1967 AND 1968 AND IN 1968 AND 1969

Position[1] in zone	No. of pairs of means	Vegetative buds	Latent buds	Female[2] buds	Total buds	Non-bud-bearing shoots (%)
1967 - 1968[3]						
L	7	-1.143	0	+0.125	-2.000	0
W I	7	-1.733**	+0.083	+1.208	+0.083	0
I I	8	-0.376	-.713*	+0.849	-.236	+3.9
W II	8	-.244	-.756**	+1.132	+.134	-17.6
I II	8	+.088	-.151	+0.817	+.754**	-26.3*
W III	7	-.042	+.166	+.555	+.674**	-41.5**
I III	7	+.007	+.549**	+.216	+.773**	-55.2**
W IV	7	+.010	+.340*	+.195	+.556**	-36.7**
I IV	7	+.021	+.300*	+.022	+.361*	-25.4**
W V	8	+.045	+.267*	+.019	+.336*	-21.6**
ALL	8	+.025	+.180*	+.229	+.494**	-31.9**
1968 - 1969[4]						
L	4	-0.500	-0.500	-1.250	-2.250	0
W I	4	+.959*	+.333	-1.542	-0.250	0
I I	4	+.074	+1.240*	-1.460	-.148	0
W II	4	+.122	+0.758	-1.114	-.022	+21.4
I II	4	-.030	+.318	-0.962	-.700*	+34.6
W III	4	-.040	-.120	-.677	-.778*	+43.5*
I III	4	-.026	-.558	-.066	-.635	+51.5**
W IV	4	-.169	-.329**	-.124	-.505*	+42.2**
I IV	4	-.044	-.190	-.024	-.258	+22.1
W V	4	-.052	-.084	-.008	-.185	+12.5
ALL	4	-.080	-.134	-.271	-.479*	+32.2**

[1] L = leader, W = whorl, I = internode

[2] Differences not tested for significance since all 1968 values were zero.

[3] In the 1967-68 comparisons, a negative sign indicates a larger value for 1968.

[4] In the 1968-69 comparisons, a negative sign indicates a smaller value for 1968.

when female buds are not developed more buds are able to develop vegetatively, but at the same time, more remain latent. From the magnitudes of the differences, it seems that in whorl I relatively more vegetative buds occur when female buds fail to develop, while in internode I and whorl II more latent buds occur. This is consistent with the relative vigour of the shoots involved and with the numbers of shoots of different vigour contained in each mean.

For positions from internode II down (Table 5.8), the numbers of lateral buds (total) per shoot were smaller in 1968 than in the other years. Thus, the numbers of each kind of bud produced per shoot are smaller when cones are carried by a tree. There appears to be no compensatory effect between female buds and vegetative or latent buds in this part of the zone. All were reduced per shoot in 1968, but the latent buds were reduced to the greatest extent (significant differences occurred only for this bud type). When all shoots are combined, there is also an overall reduction in numbers of lateral buds in the cone-bearing year. The reason for this result is the fact that the data in Table 5.8 are based on all shoots produced in each of the years concerned. In 1968, however, a major effect of cone-bearing was the great increase in the proportion of shoots produced which bore no lateral buds. The percentage differences in numbers of non-bud-bearing shoots between the years under study are also given in Table 5.8. The large number of non-lateral-bud-bearing shoots in 1968 is evident from the many very significant differences and from the magnitudes of the percentage values. In internode III over 50 per cent more bud-free shoots were formed in 1968 than in either 1967 or 1969.

In order to complete the analysis of the effects of cone bearing on lateral-bud production, the effects of non-bud-bearing shoots were eliminated by re-working the data of Table 5.8 on a buds per bud-bearing shoot basis (Table 5.9). Some major effects of this change are immediately apparent when the data in the two tables are compared. In the lower zone positions, the differences between numbers of latent buds are reversed in sign in the two Tables. Thus, throughout the zone, the numbers of latent buds formed per bud-bearing shoot were greater in 1968 than in 1967 or 1969, significant differences being found in four cases in the first comparison and in two cases in the second. The all-shoot comparisons were also both significant, each with a different sign from that shown in Table 5.8.

For vegetative buds, Table 5.9 shows some changes in sign over data in Table 5.8, but the magnitudes of the changes are not great. The tendency for more vegetative buds to be produced per shoot in 1968 is evident a little further down the zone, but in the lowest parts of the zone (internode IV and whorl V) the reverse tendency is stronger, but far from significant. Overall, the 1967-1968 comparison shows significantly more vegetative buds produced per bud-bearing shoot in 1968. The 1968-1969 comparison supports this finding, but not at a significant level.

The uniform, and largely significant, finding that total lateral-bud numbers were smaller in 1968 (Table 5.8), is shown in Table 5.9 to be invalid when bud numbers are expressed on a bud-bearing shoot basis. There is clearly no consistency between the results of the two comparisons in this regard and the magnitudes of the differences are generally reduced leading to the conclusion that when only bud-bearing shoots are considered, there is no difference in the total number of lateral buds formed per shoot in cone-bearing and non-cone-bearing years.

It should be noted that the data in both Table 5.8 and Table 5.9 refer to all vegetative and all female buds formed. A small percentage of these fail

TABLE 5.9. MEAN PAIRED DIFFERENCES BETWEEN MEAN NUMBERS OF LATERAL BUDS PER BUD-BEARING SHOOT IN THE FEMALE ZONES OF SEVERAL TREES IN 1967 AND 1968 AND 1968 AND 1969

Position[1] in zone	No of. pairs of means	Vegetative buds	Latent buds	Female[2] buds	Total buds
1967 - 1968[3]					
L	7	-1.143	0	+0.125	-2.000
W I	7	-1.733**	+0.083	+1.208	+0.083
I I	8	-0.370	-.756*	+0.921	-.219
W II	8	-.413	-.954**	+1.205	-.192
I II	8	+.086	-.518**	+0.833	+.402
W III	7	-.081	-.451	+.607	+.008
I III	7	-.032	-.345*	+.304	-.067
W IV	7	-.010	-.226	+.306	+.019
I IV	7	+.047	-.156	+.093	-.015
W V	8	+.145	-.231	+.068	+.050
ALL	8	-.118*	-.247*	+.417	-.003
1968 - 1969[4]					
L	4	-0.500	-0.500	-1.250	-2.250
W I	4	+.959*	+.333	-1.542	-0.250
I I	4	+.074	+1.240*	-1.460	-.148
W II	4	+.383	+0.758	-1.114	+.403
I II	4	-.035	+.818	-1.004	-.218
W III	4	+.034	+.480	-0.702	-.054
I III	4	-.021	+.576*	-.069	+.238
W IV	4	-.231	+.294	-.146	-.083
I IV	4	-.099	+.387	-.036	+.252
W V	4	-.105	+.118	-.022	+.008
ALL	4	+.070	+.470	-.411	+.104

[1] L = leader, W = whorl, I = internode

[2] Differences not tested for significance since all 1968 values were zero.

[3] In the 1967-1968 comparisons, a negative sign indicates a larger value for 1968.

[4] In the 1968-1969 comparisons, a negative sign indicates a smaller value for 1968.

to burst (Table 5.10), but in the limited data available, no trends associated with cone-bearing can be discerned. When only vegetative buds which burst are used in comparisons such as in Table 5.9 (1967-1968), most of the differences become smaller (without change in sign), the whorl I difference remains very significant, but that for all shoots becomes non-significant.

TABLE 5.10. PERCENTAGES OF LATERAL VEGETATIVE AND FEMALE BUDS PRODUCED ON EIGHT TREES IN 1967 AND 1968 WHICH FAILED TO BURST

Tree	Vegetative buds 1967	Vegetative buds 1968	Female buds 1967
1	6.5	0	1.8
2	10.4	2.9	0
3	0	0	1.2
4	5.6	6.7	0
8	15.4	0	3.6
10	0	9.1	0
12	4.9	7.4	4.3
13	1.6	23.7	0

On some trees, male buds (latent or formed) were present on some shoots in whorls IV and V, and internode IV (Appendix 14). Most of these shoots bore no lateral buds on their upper surfaces. So an effect of male buds may contribute to bud reductions in Table 5.8, but will not contribute to differences in Table 5.9.

In summary, it can be concluded that, in a cone-bearing year, the proportion of shoots which bear lateral buds is markedly reduced. This leads to a reduction in numbers of lateral buds formed per shoot in the female zone. However, on a bud-bearing-shoot basis, the numbers of lateral buds formed remains approximately equal in different years. When cones are present, no (or very few) female buds are formed, most of the buds remain latent, but some develop vegetatively to cause an increase in the numbers of vegetative buds produced in comparison with a non-cone year. This latter is especially true on the more vigorous shoots in the upper parts of the zone. When cones are not present, many lateral buds develop reproductively and this reduces the numbers of both vegetative and latent buds.

C. Shoot Length in Relation to Numbers of Buds

In section 5.1 E, it was stated that the number of lateral buds produced per shoot is positively related to shoot length. Morris (1951) found that the lengths of shoots produced in a flowering year in blasam fir were less than in a non-flowering year. It thus seems likely that reductions in numbers of buds produced in a flowering year are related to reductions in shoot lengths. Data on shoot lengths and on buds formed on all the shoots developed in each of five years on the upper five whorls of trees 3, 8 and 11 are given in Table 5.11. Data on the upper two whorls for six years and the upper four whorls for four years are provided for comparative purposes in Appendix 15. These show results similar to those in Table 5.11.

On trees 8 and 11 there was a distinct decrease in shoot lengths in all categories in 1966, the heaviest cone-bearing year. However, this was not true for tree 3 in which the overall mean shoot length and the order 7 mean shoot length were greatest in 1966. A contributing factor to these large values was the small number (and proportion) of order 7 shoots. Because none of the 183 lateral buds formed in the upper four whorls of tree 3 in 1965 were vegetative, all of the 1966 order 7 shoots were subterminal. Such shoots are generally longer than lateral (intermediate) shoots, several of which were borne in each of the other years.

On each tree, the 1967 shoot growth was less than that in 1965 indicating a considerable effect of the heavy 1966 cone crop on the shoot lengths of the

TABLE 5.11. NUMBERS OF SHOOTS, MEAN SHOOT LENGTHS AND MEAN NUMBERS OF TERMINAL AND LATERAL BUDS PER SHOOT, BY ORDER IN THE UPPER THREE WHORLS OF EACH OF THREE TREES IN EACH OF FIVE YEARS

		No. of shoots[2]				Shoot length(cm)				No. terminal buds[3]				No. lateral buds				No. terminal + lateral buds			
			Order				Order				Order				Order				Order		
Tree	Year[1]	All	8	7	6	All	8	7	6	All	8	7	6	All	8	7	6	All	8	7	6
3	<u>1964</u>	75	9	30	36	3.98	7.73	3.57	3.38	2.36	3.2	2.6	2.0	0.65	2.0	0.6	0.4	3.01	5.2	3.1	2.4
	1965	72	8	23	41	4.13	8.91	3.75	3.40	2.46	3.4	2.5	2.3	1.49	2.6	1.6	1.2	3.94	6.0	4.0	3.5
	<u>1966</u>	46	8	12	26	4.28	7.89	4.60	3.03	2.37	3.0	2.9	1.9	1.26	3.2	1.7	0.5	3.63	6.2	4.6	2.4
	1967	46	8	24	14	2.75	4.86	2.20	2.46	1.94	3.0	1.8	1.6	1.06	2.0	0.8	1.0	3.00	5.0	2.5	2.6
	<u>1968</u>	44	8	16	20	3.47	5.38	2.80	3.25	2.02	3.0	2.1	1.6	0.54	1.6	0.3	0.3	2.57	4.6	2.4	1.9
8	<u>1964</u>	42	7	11	24	2.96	5.87	2.69	2.23	1.98	2.9	2.5	1.5	0.64	2.0	0.6	0.2	2.62	4.9	3.2	1.7
	1965	41	7	21	13	2.94	5.86	2.42	2.22	2.27	3.3	2.4	1.5	1.17	1.9	1.0	1.0	3.44	5.1	3.5	2.5
	<u>1966</u>	34	7	11	16	1.73	3.01	1.47	1.34	1.65	2.9	1.6	1.1	0.74	1.7	0.6	0.4	2.38	4.6	2.3	1.5
	1967	23	6	11	6	2.43	3.78	2.14	1.62	2.39	3.0	2.4	1.8	1.30	2.2	1.0	1.0	3.70	5.2	3.4	2.8
	<u>1968</u>	22	4	9	9	2.14	4.22	1.72	1.62	1.54	3.0	1.1	1.3	0.46	2.0	0.0	0.2	2.00	5.0	1.1	1.6
11	<u>1964</u>	238	12	80	146	4.29	15.25	4.86	3.08	2.00	3.9	2.7	1.5	0.82	6.5	0.8	0.4	2.83	10.4	3.4	1.9
	1965	214	11	76	127	4.11	13.26	4.60	3.03	2.28	3.9	2.9	1.7	1.55	7.5	1.8	0.9	3.83	11.4	4.7	2.6
	<u>1966</u>	173	11	58	104	2.29	5.29	2.65	1.77	1.70	3.0	2.2	1.3	0.46	3.2	0.5	0.1	2.17	6.2	2.7	1.4
	1967	128	10	34	84	3.22	6.59	3.21	2.82	2.34	3.0	2.5	2.2	1.09	2.3	1.3	0.8	3.43	5.3	3.8	3.1
	1968	86	10	24	52	4.26	11.35	3.70	3.15	2.37	3.9	2.5	2.0	1.66	4.3	1.4	1.3	4.04	8.2	3.8	3.3

[1] Years underlined indicate cone-bearing years for the tree concerned.

[2] Shoots which completed development: a few shoots were broken during the course of the study by one of a variety of causes (e.g. snow and ice, wind and towers, handling, squirrels) and thus the numbers do not necessarily indicate the total shoot production.

[3] Includes subterminal buds.

following year. The lesser bearing in 1964 did not have such an effect on the 1965 shoot lengths, nor is there much evidence of effect in 1964 itself. Tree 3 was the only tree which bore fairly heavily in 1964: it shows a slight reduction in that year. The 1968 cone bearing, similarly, had little effect on shoot length. Of the two trees which bore in that year, only tree 8 shows a decrease in shoot length.

The terminal-bud data are similar to those for shoot length, there being some reduction in numbers of terminal buds in cone-bearing years. Relationships between numbers of terminal buds and shoot lengths are shown in Fig. 5.17. For both trees 3 and 8 residual variances for the curves are homogeneous and no significant differences exist between the slopes for the different years. This indicates that the populations can be considered similar in each year, and further, that changes in shoot length contribute to a similar relative extent in each year to changes in numbers of buds. However, only about 60 per cent of the variation in bud numbers is attributable to variations in shoot length: other factors (not cone-bearing) account for the remainder. The data for tree 11 are not so uniform since the residual variances are heterogeneous (Chi-square = 12.80, probability = 0.02). The variances range from 0.246 for 1966 to 0.393 for 1965. Elimination of either of these years results in homogeneity in the variances for the remainder. Tests among the two sets of homogeneous populations showed the slope for 1968 (a non-cone-bearing year on this tree) to be significantly different from those for 1964 and 1965. Examination of scatter diagrams shows this to be related to the bearing of at least two terminal buds on all shoots longer than 3 cm in 1968: in the other years (also vigorous growth years) many shoots between 3 and 4 cm bore only one bud. This difference is clearly not related to cone-bearing, but the

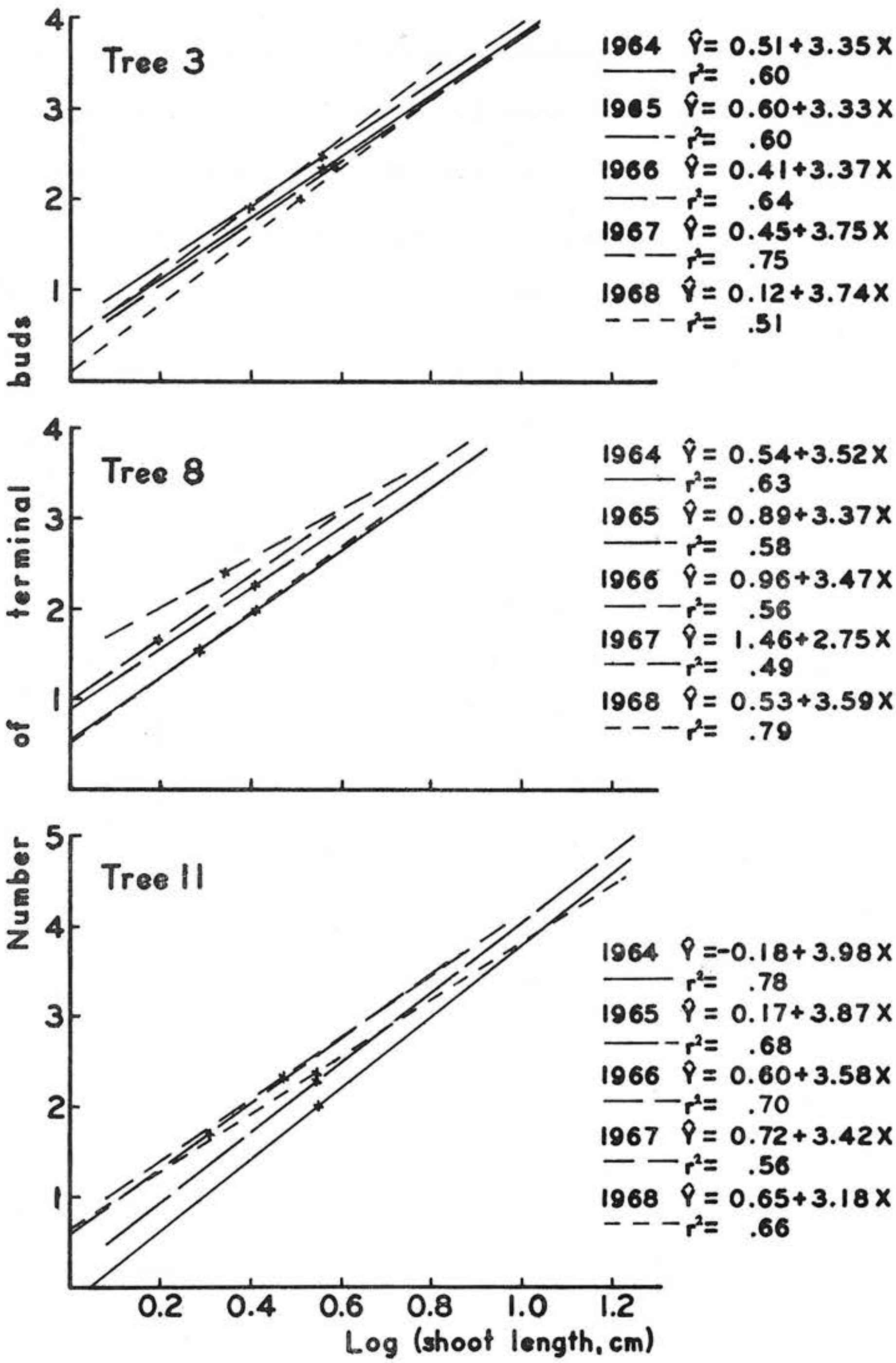

Figure 5.17. Relationships between numbers of terminal buds and shoot length for trees 3, 8 and 11 in the years 1964 to 1968.

relatively low 1966 variance might be associated with cone-bearing in that it appears to be associated with data from shoots no longer than 8 cm as opposed to shoots up to 18 cm in 1964, 1965 and 1968. Apart from this, the data for tree 11 support those for trees 3 and 8 in indicating that terminal bud numbers are related to shoot length and are not influenced in a separate fashion by cone-bearing.

The effects of cone bearing on production of lateral buds are more clearly evident in Table 5.11 than are the effects on terminal-bud production. Again, the values for tree 3 for 1966 do not conform, except in the case of order 6. Clearly, the relationships between shoot length and lateral-bud numbers are different in different years. For example, in each tree there is little difference between the shoot-length means in 1964 and 1965, but the means for lateral buds are all much less in 1964 (cone-bearing year) than in 1965. Regressions for numbers of lateral buds on shoot length are depicted in Fig. 5.18. As in the case with terminal buds, the coefficients of determination are all of a similar order indicating a similar degree of association between the variables in the different years. However, for lateral buds the association is greater than for terminal buds, about 70 per cent of the variation in lateral-bud numbers being explained by variation in shoot length. The relationship for lateral buds is characterized satisfactorily by a straight line, whereas that for terminal buds is curvilinear.

Figure 5.18 shows the relationship between years in each tree to be quite variable. Tree 8 is the only one for which the residual variances are homogeneous and thus is the only tree in which all the regressions can be statistically compared. For tree 3, the residual variance for 1966 is considerably

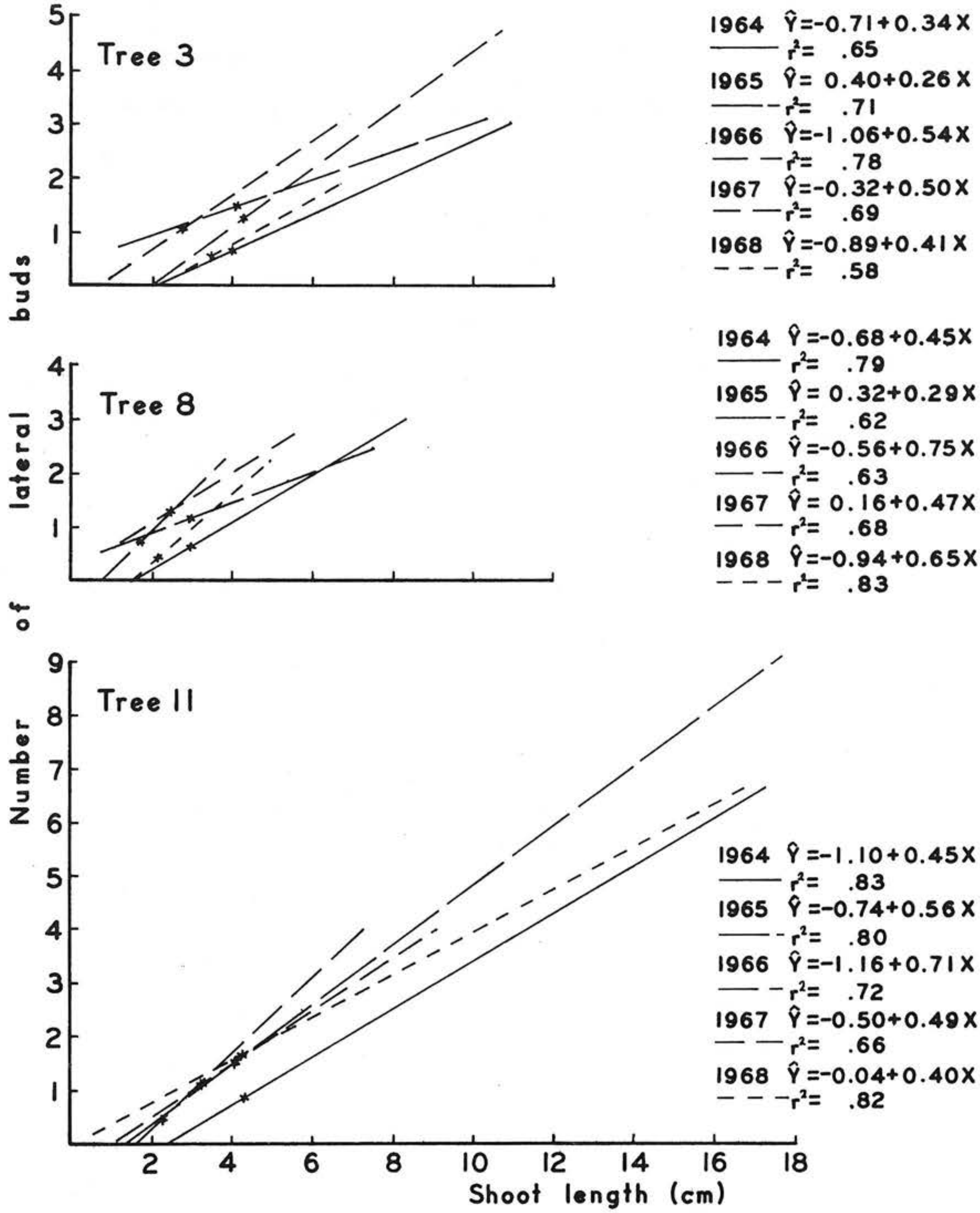

Figure 5.18. Relationships between numbers of lateral buds and shoot length for trees 3, 8 and 11 in the years 1964 to 1968.

higher than for other years, if the 1966 data are eliminated the remainder show homogeneous variances. In tree 11, the residual variances for 1964 and 1968 and for 1966 and 1967 are respectively homogeneous: the overall lack of uniformity indicates distinctly different distributions in different years. This tends to be related somewhat to shoot lengths since variances are least, and closest (0.280 and 0.250), in 1966 and 1967 when mean shoot lengths were least. The large residual variance in 1966 for tree 3 is associated with a wide scatter of points for the longer shoots formed in that year. This can be interpreted as an effect of cone bearing in that cone bearing resulted in a much greater variation in bud numbers on long shoots. When long shoots are not formed, as in 1966 on tree 11, the variation is less.

Where variances were homogeneous, tests of differences between slopes were undertaken, as for terminal buds, using covariance. In all cases involving several years, slopes were significantly different indicating that the response to differences in shoot length was not similar in different years. There is some evidence to support the occurrence of a greater slope in cone-bearing years than in non-cone-bearing years. This is shown for tree 8 in which there is no significant difference between the slopes for 1966 and 1968,but both of these slopes are significantly greater than all others. This tree bore most heavily in 1966, quite heavily in 1968, but only lightly in 1964. On tree 11, the 1966 slope is very significantly greater than that for 1967. Although having a different residual variance, the 1966 slope for tree 3 is apparently greater than all others.

This indicates a tendency for the shorter shoots produced in a cone-bearing year to bear fewer lateral buds, and longer shoots to bear more lateral buds, than shoots of comparable length in a non-cone-bearing year (the main-axis shoots on the whorl branches). The longer cone-year shoots would be order 8 shoots and thus relatively more vigorous because of position than non-cone-year shoots of comparable length, the majority of which would be subterminal order 7 shoots. It seems that positional vigour may act to some extent independently of shoot length. This is shown to a degree in the lateral-bud data of Table 5.11.

Both terminal and lateral bud numbers are thus related to shoot length, the latter more strongly. In the former, when shoot length is reduced as a result of cone-bearing the regression coefficient is unaltered. With lateral buds, however, cone-bearing tends to increase the coefficient or to affect the distribution while the relationship remains equally strong. These effects appear to be related to differential vigour among shoots of comparable length in different years. About 40 per cent of the variation in terminal-bud numbers and about 30 per cent in lateral-bud numbers is not accounted for by shoot-length variations.

D. Bud Type in Relation to Bud Position

Differences in the numbers and proportions of buds of different type produced in cone-bearing and non-cone-bearing years were dealt with in Section 5.2 B, while characteristic lateral-bud positions on shoots in the female zone were discussed in Section 5.1 E. Data for six consecutive years for trees 3, 8 and 11 provide a basis for relating these two factors.

The percentages of female, vegetative and latent buds produced in different bud positions were calculated for each tree in each year. Mean values were then computed for non-cone-bearing years and cone-bearing years by tree and then averaged to provide one set of data for each type of year. These data are shown in Table 5.12. When female buds were present, the first-bud position was most commonly occupied by a female bud, with latent buds occurring frequently,

TABLE 5.12. MEAN PERCENTAGE OCCURRENCES OF FEMALE, VEGETATIVE AND LATENT BUDS IN BUD POSITIONS ALONG ONE-BUDDED, TWO-BUDDED, THREE-BUDDED AND FOUR-BUDDED SHOOTS FOR THREE TREES IN THREE FLOWER-BUD-FORMING YEARS AND THREE NON-FLOWER-BUD-FORMING YEARS[1]

	No. buds on shoots	First bud Fem.	First bud Veg.	First bud Lat.	Second bud Fem.	Second bud Veg.	Second bud Lat.	Third bud Fem.	Third bud Veg.	Third bud Lat.	Fourth bud Fem.	Fourth bud Veg.	Fourth bud Lat.
Female buds present	1	50	0	50									
	2	59	1	40	40	15	45						
	3	84	11	5	41	27	32	38	40	22			
	4	67	8	25	16	42	42	17	83	0	17	83	0
Female buds absent	1	1	9	90									
	2		26	74		50	50						
	3		56	44		59	41		89	11			
	4		66	34		73	27		92	8		92	8

[1] For one tree (11) two flower-bud-forming years and four non-flower-bud-forming years.

particularly on shoots with one or two buds. Vegetative buds were rare in this position, but less so on more copiously budded shoots. In the second-bud position vegetative buds were more frequent, but, except on shoots with four buds, less common than female or lateral buds. Vegetative buds were the most common type of bud in both the third and fourth bud positions, with latent buds least abundant. There is, then, a definite tendency for female buds to occupy proximal positions and for vegetative buds to occupy distal positions (especially on longer shoots). The proportions of latent buds are higher on less vigorous (one-budded or two-budded) shoots than on more vigorous ones. This kind of bud distribution has been observed on all trees examined.

In years when female buds are largely absent (tree 3 bore three female buds in 1965, but that year was classified as non-cone-bearing), the proportions of both vegetative and latent buds in the first-bud position rise, but that of the former to a greater extent. In the other bud positions, the proportions of vegetative buds also increase, while those of latent buds rise only slightly or decrease. This indicates that many female buds are replaced by vegetative buds in all positions, although some remain latent, particularly on weaker shoots or in more proximal positions on stronger shoots. It should be noted that the value of nine per cent for vegetative buds occurring on single-budded shoots was made up primarily of buds in the more distal position. It was stated in Section 5.1 E that proportionally more shoots with distally situated single buds occurred in cone-bearing (non-female-bud-bearing) years.

It is evident that the position of the bud on the shoot has an influence on its likely development and differentiation into a reproductive or a vegetative form in any given year.

5.3 SUMMARY

1. Subterminal-bud and lateral-bud initiation are described. Either kind of bud may fail to develop and become latent. Differentiation of tissues of vegetative, megasporangiate and microsporangiate buds and development to the overwintering state are described. Occurrences of strobili in atypical positions are described.

2. The capacity to produce megasporangiate buds is contingent upon maintenance of apical dominance.

3. The number of upper lateral buds per shoot is positively related to shoot length. The majority of the shoots produced in the female zone bear zero, one or two buds. Buds on two-budded shoots tend to occur one at about 30 per cent, the other at about 75 per cent of the distance along the shoot. Most single-budded shoots carry their bud at about the 30-per-cent distance.

4. The numbers of shoots in the female zone fluctuate widely between trees and between years. The numbers declined during the period of study. The number of lateral shoots, and to a lesser extent, terminal shoots is less in a flowering year. The degree of reduction depends on the cone-bearing intensity on the subtending branches.

5. In the upper part of the female zone, when female buds are formed (non-cone-bearing year), both vegetative and latent buds are fewer, but the total number of buds per shoot is equivalent to that in a cone-bearing year when no female buds are formed.

6. In the lower part of the female zone, in a cone-bearing year, the number of upper lateral buds per shoot is smaller, but the number of bud-free shoots is greater. The number of buds per bud-bearing shoot is equal in cone-bearing years and non-cone bearing years; in the latter, female buds take the place, primarily of latent buds.

7. Lengths of shoots of all orders decrease in a cone-bearing year. The number of terminal and subterminal buds (together) per shoot is related to shoot length ($\hat{Y} = a + b \log X$). Regression coefficients for different years are not significantly different, thus cones do not affect the relationship except through shoot length.

8. Linear regressions of numbers of upper lateral buds per shoot on shoot length show considerable variation between years, with a tendency for greater slopes in cone-bearing years. Even though short, the positionally more vigorous shoots in a cone year have the capacity to produce more buds than positionally less vigorous shoots of a similar length in a non-cone-bearing year.

9. The position of a bud on a shoot has an effect on its likely development and differentiation. Female and latent buds tend to be proximal, while most vegetative buds are distal.

CHAPTER 6

DISCUSSION

The objectives of this discourse were to examine (1) relationships between tree character and cone production, (2) factors operating in the female zone which affect cone production and cone quality, and (3) inter-relationships between vegetative and reproductive growth which might influence seed production (page 2). These three facets of seed production in balsam fir have formed the bases for the three preceding chapters. The discussion of the results follows essentially the same sequence, but it has been thought desirable to first discuss the qualities of the three seed years involved in the study. Sections follow on tree character, female-zone character, and vegetative and reproductive growth in relation to cone production. The latter, while dealing largely with the results of Chapter 5, also includes some aspects of the results of Chapters 3 and 4. In it, emphasis is placed on the initiation and development of different kinds of buds, on the biennial growth cycle of mature trees of the species, and on how the findings of this study relate to the physiology of the upper crown as this is currently understood.

6.1. THE SEED YEARS STUDIED

The occurrence of good seed years in 1964, 1966 and 1968 clearly supports the tendency for biennial bearing in balsam fir (Zon, 1914; Morris, 1951; Hughes, 1967) and extends the range of even-numbered seed years recorded for the species. In each seed year, cones were borne on trees of each crown class. Cones have not previously been noted on suppressed balsam fir trees. While the low percentage (2) of suppressed trees bearing in 1964 and 1968 might be discounted, the 20-per-cent figure for 1966 cannot be. This reflects the extremely heavy bearing in 1966, with far higher percentages of bearing dominant, co-dominant and intermediate trees than recorded by Morris (1951). Morris's values are also exceeded slightly by those for 1964 and 1968.

By converting the estimated numbers of cones given in Table 3.1, making due allowance for insect-killed cones (based on data for the 13 sample trees), and using a value of 234 seeds per cone (Powell, 1970) a rough indication of seed quantities produced by the studied stand can be made. About 6.9 million seeds were produced per hectare in 1964, 18.2 million in 1966 and 4.5 million in 1968. (Estimates from seed traps in the stand gave 16.0 million in 1966 and 4.9 million in 1968 (unpublished data of the author).) Using the average value given for balsam fir by Anon. (1948), the numbers of kilograms of seeds produced per hectare in 1964, 1966 and 1968 were approximately 52, 139 and 34. These values are all far in excess of the range of 11 to 18 kilograms per hectare given by Hughes (1967). However, Hughes examined stands containing an average of 246 balsam fir trees over 5 cm d.b.h. per hectare, whereas the stand under study contained 560 balsam fir per hectare (Table 2.1). Therefore, for comparable numbers of trees, the 1968 value falls within the range and the 1964 value slightly exceeds the maximum value given by Hughes: the 1966 value is about three times the adjusted value. The three seed years studied, therefore, all ranked high in comparison with seed years included in the investigations of others, and 1966 was an exceptionally heavy seed year.

6.2 TREE CHARACTER AND CONE PRODUCTION

When cone bearing on individual trees is compared between seed years it is found that most trees react in a similar fashion. Only four trees in 1964, and six in 1968, out of 418, bore more cones (by classes) than in 1966: the majority bore fewer cones. However, while the order of change tends to be similar, thus indicating a similar response to influential factors, the magnitude of change may vary tremendously from tree to tree. This is especially true for trees which have only relatively recently become cone bearing. This corresponds with the observation that seed production in young trees is sparse and sporadic (Matthews, 1961; 1963a), but here, owing to the shade tolerance of the species, age is not necessarily the prime factor. Trees which are in, or have recently moved out of a relatively poor situation, appear to respond to flowering stimuli to a variable, though often considerable, extent, while response among better situated trees is more uniform. It is in the latter that bearing biennially commonly occurs.

Cone production was found to have the strongest individual relationships with tree-character variables denoting overall tree size. The best measured variable in each seed year was tree height, with d.b.h. and crown length ranking second or third. Crown class was always highly ranked. These findings are in agreement with those of others (e.g. Garman, 1951; Morris, 1951; Fowells and Schubert, 1956; Messer, 1956b; Kozak et al., 1963; Waldron, 1965) who have found cone production to be positively related to tree size, usually expressed as crown class. In this study, however, the best single variable has accounted for no more than 50 per cent of the variation in cone production in the poorest seed year, and 66 per cent in the best seed year.

Cone production was much less strongly related to crown width than to the other major tree-dimension variables. A similar difference between crown width and crown length as these affect cone production is evident in the data of Fowells and Schubert (1956) for Abies concolor. It appears to result from relatively greater variation in crown width than in crown length for trees of any given status, especially in a heterogeneous stand and for a shade-tolerant species.

Relationships between cone production and other variables such as age, ring widths, foliage colour, basal and upper crown conditions and leader lengths, though all positive, were relatively poor. Apart from age which has generally been shown to be associated with cone production (Baldwin, 1942; Hagner, 1955), the other variables have not previously been related to cone bearing, although Hagner (1955) showed a direct relationship between numbers of cones per tree and vigour class, and Fowells and Schubert (1956) showed a positive relationship between cone bearing and foliage vigour. Their vigour rating involved an assessment of the amount and colour of foliage and is thus akin to foliage colour and crown condition as used here.

Male and female strobilus colours, which vary widely between trees and appear to be unrelated one to the other on individual trees (see also Griffith, 1968), were found not to be related to cone bearing. There was, however, some tendency for deeper male-strobilus colours to be associated with larger trees, but strobili of the lightest colour occur on some dominant trees, while deep coloured strobili occur on suppressed trees in deep shade. Strobilus colour is therefore a genetically controlled factor: the preponderance of certain colours in species (Franklin, 1964, Santamour, 1966), stands or regions (Ching et al.,1966) may be explainable in genetic terms.

Between 59 and 81 per cent of the variation in cone production is accounted for when 16 variables (measured, calculated and qualitative) are included in multiple regression. This is reduced to 56 to 76 per cent when the best six variables are selected. In each case the lower percentage is for the poorest seed year (1968) and the higher one for the best seed year (1966). The best six variables were not the same in each year, probably on account of close intercorrelations among the major tree-dimension variables and variables calculated from them. However, in each case a variable incorporating tree height was ranked first, with basal crown condition in second or third position. Some other variables which ranked relatively low in simple regressions also occurred in the best six combination. Thus, because of high intercorrelations, one or two tree-dimension variables only were selected among the best. The other variables selected were ones which, singly, accounted for little variation in cone production but which, in combination, provided valuable additions to the tree-dimension variables. It is evident that, for predictive purposes, equations using tree height, crown condition, and a variable expressing current vigour such as leader length or ring width would be satisfactory.

Principal component analysis was successful in simplifying the tree-character data into four biologically interpretable components with eigenvalues greater than one. These account for 81 per cent of the variability in tree character. Cone production was significantly related to only two of these: the first, interpreted as a general size index, and the third associating the tree age with height, stem diameter and crown class. The second component, an index of the nature of the upper crown, and the fourth, a general measure of crown condition, were not significantly related to cone production despite the value of crown condition in multiple regression. It should be remembered that trees with extremely poor (lacking or flattened) upper crowns incapable of carrying cones were not included in either analysis.

The results of the principal component analysis draw attention to the major effects of tree size in influencing cone production. Important contributions were made to the first component by diameter at breast height, crown length, crown class and ring width, and to the third component by height, diameter, age and crown class. Size and current vigour as expressed by ring width, exerted the greater effect in an excellent seed year, but in poorer seed years the influence of size coupled with age became more apparent, though still not as important as size coupled with the current vigour. This can be interpreted in the light of comparisons of simple regressions of cone production on tree-size variables and on age for the various seed years. In average seed years, cone bearing is mainly restricted to the larger trees in the stand. In a better seed year these trees produce larger crops and many smaller trees also bear cones. Among these smaller trees, those that have been growing more vigorously over a number of years tend to bear more cones than other trees of similar height. Many of the more vigorous trees are younger trees (age at stump height) which therefore bear more cones than many older trees of similar status. The increase in cone bearing on these young trees is relatively greater (in the scale of cone-number classes used) than that on many older trees: many lack cones in poorer seed years.

Once again the variation (between trees and between years) in cone bearing, particularly on smaller trees is emphasized, but here it is clear that age, even in a shade-tolerant species plays a part. The seed production is sporadic, but not necessarily sparse (e.g. Matthews, 1961; 1963a) if the trees concerned have been growing reasonably vigorously. When conditions are permissive flowering can be heavy on such trees.

From the results of the principal component analysis it is clear that the modifying effect of age should be included when developing equations for predictive purposes, while crown condition is of doubtful value. The variables used in future work should include tree height, diameter at breast height, crown class, crown length, recent ring width and age. Obviously, if predictions of cone bearing are to be made, some assessment of the numbers of buds formed on sample trees would have to be made in order to select the appropriate equation. It must be stressed that the tree-character variables used account for only some 65 per cent of the variation in cone production (as expressed by the cone classes used) and that the standard errors of estimate are large.

6.3 FEMALE-ZONE CHARACTER AND CONE PRODUCTION AND QUALITY

From the results in Chapter 4 it is apparent that the amount of variation in cone production accounted for could be increased by including variables expressing different aspects of the branching characteristics of the tree and of the female zone of the tree. It has been shown that the mean number (or range in number) of branches per whorl tends to be characteristic of the tree. Thus some trees intrinsically have more branches per whorl, and hence more branches capable of carrying cones than others. Similarly, although related to leader length, some trees tend to form more internode branches than others of similar status. As many as 38 branches have been observed in a single internode; far more than implied by the "occasional internode branching" of Bakusis and Hansen (1965).

Female cones were found by Morris (1951) to occur in the upper 1.2 to 1.5 m of the crown in balsam fir. In this study, the length of crown bearing female cones has been found to be extremely variable. On young trees bearing for the first time (at age 15 by ring count, 11 by whorl count, and height 2.1 m, which compares well with the earliest recorded bearing by the species (Roe, 1948b) at age 15 by whorl count, and height 2.0 m), and on older trees bearing few cones, it may be as short as 26cm (with the crown above the cones included), but on trees producing many cones, as long as 2.0 m. Thus the cone-bearing zone increases in length as the tree becomes capable of producing more cones. Even on established cone-producing trees the cone-bearing zone varies considerably between seed years, but the zone capable of producing cones has a more constant length. However, it varies according to the recent vigour of the tree which affects the internode lengths which occur within the zone. For this reason, length, even of the portion of the crown capable of producing female flowers, is less satisfactory than measures such as numbers of whorls or numbers of internodes, which automatically exclude major effects of recent vigour. This study has shown, however, that Morris's (1951) range for the female zone (capable of producing cones) of regularly producing trees should be broadened to 0.6 to 2.0 m.

A further difficulty with zone length is that it is generally different for cone bearing on whorls and for cone bearing on internodes. It has been found that female-cone bearing occurs further down the crown on whorl branches than on internode branches. The reverse is true for male bearing. Male flowers occur higher on internode branches than on whorl branches. Because of this the two zones tend to overlap, especially in better seed years, but rarely is there overlapping on any one kind of branch. Where this does occur at the same level (cf. Morris, 1951) the male flowers are always on weaker side shoots and the female cones on strong main shoots. The length differences are associated with branch vigour.

Data on the number of female-bearing and male-free whorls and internodes indicate that a gap existed between the lowest female and highest male occurrence on both kinds of branches in poorer years, while in 1966 there was slight overlapping. The gaps were closed by both downward extension of female bearing, and upward extension of male bearing. In a heavy flowering year, therefore, the male zone not only increases in size as a result of downward extension, as indicated by Blais (1952) and shown in the data presented by Greenbank (1963), but also by upward extension. The same has been found to be the case for the female-bearing zone. The downward extension in good seed years is thus comparable to that recorded by Waldron (1965) for Picea glauca and by Kozak et al. (1963) for Pseudotsuga menziesii. Upward extension is shown by the tendency for more trees to form cones on leading shoots in a heavy seed year.

For the trees used in this study, the zone capable of bearing cones ranged from three whorls and two internodes on some smaller trees to six whorls and five internodes on some larger trees. There thus appears to be a gradual increase in zone size as the tree becomes larger. However, zone size did not increase in proportion to tree size. The gradual increase in zone size takes place over a long period of time, such that there is little short-term change in the size of the potential cone-bearing zone. It is the degree to which the potential cone crop is realized which is responsible for short-term fluctuations in the actual cone-bearing zone.

The proportion of branches in the female zone which bore cones was greater in 1966 than in 1964 and 1968. Thus in a better seed year the intensity of branches bearing cones increases just as does the intensity of branches bearing male strobili (Greenbank, 1963). The intensity of bearing is not uniform throughout the zone. Proportionately more branches in the upper part of the zone bear cones than in the lower part of the zone. Similarly, proportionately more shoots on branches in the upper part of the zone bear cones than do shoots on branches in the lower part of the zone. This decrease in intensity of bearing shoots with distance down the zone was apparent in each seed year, and again, parallels the situation in the male zone as shown in Table 1.3 (Greenbank, 1963).

The number of cones formed in a seed year was positively, and logarithmically or exponentially, related to the various measures of zone size (length, number of whorls and internodes, number of bearing whorls and bearing internodes, number of bearing whorl and bearing internode branches, and number of bearing branches). In several cases the relationships were weaker for 1966 and regression coefficients (curvilinear relationships were rectified) were smaller. This reflects the relatively large zones formed, on almost all the trees used, in 1966 and gives some indication that an upper limit to the rate of increase exists on larger trees. It is logical to expect this to be the case since the presence of the upward-extended male zone will block the downward extension of the female zone. Thus there seems to be a limit to the possible extension of the female zone in terms of number of whorls or branches. Even if extension into the male zone does occur, bearing is limited to a few main shoots which cannot carry many cones, thus the rate of increase in numbers of cones with increase in numbers of branches will decline.

The data show a great increase in intensity of bearing on individual branches in a better seed year. Thus more shoots on a given branch bear cones and bearing is heavier on stronger shoots. This accounts for much of the increase in numbers of cones. On many trees in 1966 it appeared that a saturation point had been reached in terms of numbers of cones on individual branches, all available space having been effectively used up. It is possible that further increase in cone-bearing intensity was limited, and again, a fall off in rate of increase in cone numbers with any increase in zone size that was possible would be indicated. With a larger sample, the existence of upper limits to the size of the zone and hence to numbers of cones borne may have been more evident.

Fowells and Schubert (1965) showed a tendency for the numbers of cones borne per Abies concolor tree to reach maximum values on trees between 60 and 75 cm d.b.h. and then to fall off on trees of greater diameter (up to 137 cm). This indicates that cone-bearing capacity probably decreases with declining tree vigour. From the results of the present study it would seem that, with declining vigour, the size of the female zone would diminish, and the relative upper limit of the male zone would rise. This would account for some reduction in cone-bearing capacity. It seems possible that some of the trees used in this study have reached the stage of maximum cone production (Baldwin, 1942; Anon., 1948). Tree 5 (18 cm d.b.h.), without whorl I or internode I, bore 631 cones in 1966. This compares favourably with the maximum of 987 cones recorded for an A. concolor tree, of 64 cm d.b.h., by Fowells and Schubert (1965). Abies concolor trees reach, on average, diameters of 100 to 150 cm, while balsam fir, on average, reach 30 to 45 cm (Fowells, 1965).

The numbers of cones produced were greater on the south aspect than on other aspects in 1964 and 1966. This agrees with the findings of others for various species growing in northern latitudes (Gal'pern. 1949; Garman, 1951; Sarvas, 1962; Winjum and Johnson, 1964), and also, with respect to insolation, with greater production of flowers in the north in Pinus radiata in the southern hemisphere (Fielding, 1967). In the present study, the numbers of branches (internode) were also found to be greater on the south side. This undoubtedly contributed to differences in cone production, nevertheless, cone-number differences were still apparent after adjustment for branch-number differences. This indicates a greater intensity of cone bearing on the south side in years of better cone production. This was related more with internode branches than with whorl branches. The former are shorter and more numerous than whorl branches and are thus more subjected to shading. Smith and Stanley (1969) postulated that an essentially east-west gradient in cone numbers in seed-orchard-grown Pinus elliottii in Florida was probably related to the preponderance of morning sunshine and afternoon cloudyness in that southern region: mutual shading removed the east-west gradient. Fielding (1967) also found shade to reduce flower formation.

Despite greater numbers of internode branches, about 65 per cent of the cones formed are carried by whorl branches. These are always more vigorous than internode branches of the same age. The internode branches, nevertheless, are much more important in cone production in balsam fir than in Pseudotsuga menziesii: Winjum and Johnson (1964) found only 9.1 ± 6.1 per cent of the cones on internode branches on the latter species. The relative importance of whorl branches and internode branches changes with position in the zone in balsam fir. Among whorls, heaviest bearing occurred on the third whorl, while the second internode was the most important internode. Bearing thus tends to be heaviest in the middle region of the zone. This is brought about as a result of relative vigour and numbers of shoots available. Winjum and Johnson (1964) also found more cones in the middle region of the cone-bearing portion of Pseudotsuga menziesii crowns (see also Kozak et al., 1963; Hard, 1964).

More cones were borne on one-year-old side shoots (order 7) than on any other category. This reflects the quantity of such shoots available, since a greater percentage of one-year-old main-branch extensions (order 8) carry cones.

These two orders of shoots are the most vigorous. Shoots of lower morphological category carry fewer cones, though more of such shoots carry cones in a better seed year. The highest male strobili on a tree usually occur on shoots of low morphological category. The capacity to produce female cones is clearly related to shoot vigour as expressed by order and length. This will be further discussed at a later stage.

The number of scales (bract-scale complexes) was used throughout this work as a measure of cone size. All bracts in Abies are initiated before resumption of strobilus growth in the spring (Matsuura, 1961; Powell, 1970) and thus cone size in terms of numbers of scales may be determined throughout the growing season. Number of scales has the obvious advantage that it is free from the effects of environmental factors during the year of seed production. Despite this, the measure has rarely been used, preference being given to more readily obtainable measures of full cone size such as length and weight.

The mean number of scales per cone is linearly and positively related to cone length, cone diameter, and cone weight with and without seeds. However, the among-tree relationships differ in varying ways between years thus no common regression coefficient can be assumed. This agrees with Andersson's (1965) findings for between-year differences in cone properties of Picea abies. The between-year differences found in the present study were, however, not sufficient to greatly affect the shape and appearance of the cones on any one tree. The latter remain distinctive regardless of the size of the cone or the year of development. The cones, bracts, scales and seeds of any one tree all have a distinctive shape and appearance. During the course of this study, cones and cone parts could all be readily associated with their mother tree. This is consistent with the finding of Simak (1953a) that seed form and detail were constant in the cones of single Pinus sylvestris trees (see also Simak and Gustafsson, 1954).

There was little evidence that the mean total number of scales per cone differed consistently between years (see also Sarvas, 1962, page 105 for Pinus sylvestris cones). However, when cone length, diameter and weight were adjusted for differences in numbers of scales, all were found to be significantly greater in poorer cone years than in 1966. The numbers of scales per cone are determined in the years prior to the seed years and it seems that they are largely unaffected by the numbers of buds formed per year. The mean number of scales per cone thus appears to be constant on any one tree. In contrast, the growth conditions of the year of cone development are reflected in the dimensions and weight of the cones formed. When many cones are present, cone size, in these terms is less, presumably because the resources available to the tree are required to supply a larger cone population. It is evident that the same argument could be applied to numbers of scales per cone in the year of bract initiation, especially since cone length is related to bud length (Powell, 1970). Morris (1951) found numbers of needle primordia to be less in terminal buds formed concurrently with strobilus buds. This may, however, reflect preferential use of resources by the latter. It is possible that the sample sizes used in this study or the distribution of the samples or populations within the crowns of individual trees in the different years, were such that differences, if present, were not found. It is also possible that the magnitudes of the food sinks represented by the developing buds and the developing cones are so vastly different that similarities in effects should not be expected.

Despite the between-year differences in cone dimensions, it is clear that these may still tend to be characteristic, in a relative sense of the mother tree, since all trees tend to react similarly to similar changes in conditions. Thus, while admitting between-year variation, both Plym Forshell (1953), for Pinus sylvestris, and Kantor (1967) for Abies alba stated that cone length was a genetically controlled character of the mother tree.

The mean total number of scales per cone did not differ consistently by aspect. Since more cones were carried on the south aspect, this finding supports the constancy in numbers of scales per cone and the lack of effect of numbers of buds on numbers of scales formed within the buds. Presumably more buds are formed on the south in response to better insolation on that aspect. Differences in insolation on aspects would be more apparent later in the year when bracts are being initiated. Thus one would expect a greater effect on initiation if insolation is involved. It seems feasible that lack of differences in numbers of scales could be accounted for by the greater numbers of buds: photosynthesis may be greater, but the greater amount of photosynthate is distributed among more buds and no bud receives proportionately more photosynthate for its development than similarly situated buds on other aspects.

In balsam fir, the size of the cone in terms of numbers of scales has been shown to be distinctly and consistently related to the vertical position and the upon-branch-horizontal position of the cone. In each seed year, the number of scales per cone decreased with increasing distance from the apex of the tree and with increasing distance from the apex of each branch having more than one order of shoots. The decreases in size occurred on both whorl and internode branches but usually at greater rates on the latter. Thus cones on the lower branches in one internode were often smaller than those on the whorl branches below. The decreases in cone size down the female zone were only partially associated with the fact that more shoot orders occur on lower branches: decreases occurred also for any one shoot order down the zone.

Similar decreases in numbers of scales per cone, down the tree and with order on branches, were shown for *Pinus resinosa* by Lyons (1956). The author has shown that cone length and diameter also decrease with distance down the zone in balsam fir (Powell, 1970). This agrees with the findings of Lyons (1956) for *Pinus resinosa* and those of Winjum and Johnson (1964) for *Pseudotsuga menziesii*. A reverse tendency was shown for both cone length and cone weight for *Picea abies* (Messer, 1956b; 1958). For three *Larix decidua* trees, Messer (1958) found inconsistencies in cone length and weight distributions in the crown, and Zentsch (1961) also found no clear trend in *Pinus sylvestris*. However, for the latter species, the data of Sarvas (1962) support a decrease in cone size down the zone. There is then, no clear concensus that can be drawn for all species. For balsam fir, however, the evidence is indisputable and clearly indicates the care that must be excercised in taking samples of cones for almost any purpose (cf. Owston, 1969).

While the total number of scales is a measure of overall size, the number of central scales is a measure of effective cone size since each scale in the central (bearing, or productive) region of the cone has the capacity to form two seeds. Thus the number of central scales indicates the potential number of seeds (Powell, 1970). Most researchers (e.g. Simak, 1953b; 1961; Messer, 1958; Ching, 1960; Andersson, 1965) have used numbers of seeds per cone rather than potential number, thus eliminating from consideration ovules or seeds in the productive region which have completely failed to develop or which have been completely destroyed by insects. However, Lyons (1956) and Tripp and Hedlin (1956) separated distal and proximal unproductive regions of cones from the productive region in Pinus resinosa and in Picea glauca, respectively, on the basis of scales. Sarvas (1962; 1968) has provided similar data for Pinus sylvestris and Picea abies.

In balsam fir, the number of central scales has been found to be closely and linearly related to total number of scales on any one tree, with about 90 per cent of the variation in central-scale number being accounted for by total-scale number. However, there is much between-tree within-year variation, and between-year within-tree variation. In neither case is the variation consistent, thus the changes in relationships cannot be related to differences in cone bearing. The effective cone size averages about 73 per cent of the total cone size. This is about 10 per cent less than previously given by the author (Powell, 1970). The difference is explained by the fact that the six trees from which the published data were derived were trees 1, 2, 4, 5, 7 and 12 (in 1966) which tended to have larger cones and larger productive regions than the six other trees included in the new average (see Table 4.37). The difference emphasizes the between-tree variation which exists in the relationship under discussion.

This difference is also illustrated by the fact that despite the occurrence of linear within-tree relationships, overall (between trees), the larger cones were found to contain proportionally more central scales than smaller cones. Thus, about 76 per cent of the scales in a relatively large cone were productive, whereas only 68 per cent were productive in a relatively small cone. Similar differences are not apparent in the data on Pinus sylvestris cones presented by Sarvas (1962). He found the productive region to average only 22 per cent of the scales. Data of others (Simak, 1953b; Lyons, 1956; Tripp and Hedlin, 1956; Messer, 1958; Dieckert, 1964; Sarvas, 1968) show the productive regions of the cones of other species to range from 45 to 76 per cent of the scales, and 40 to 80 per cent of the cone length. The variation is associated with differences in cone morphology.

Since number of scales per cone (both total number and central number) is related to position in the female zone, it is possible to compute equations using indices of cone position to predict cone size. Thus relative height and shoot order were both effective in this regard. No uniform index of relative height was found which was equally effective for each tree, though some were clearly better than others. This again reflects between-tree variation, especially in the relative decreases in cone size exhibited between whorls and internodes down the female zone. In some cases, the results were confounded by, for example, distinctly different numbers of branches available in successive internodes. This naturally affected the degree of uniformity of sampling possible. Because of the two-way decrease in cone size demonstrated, down the zone and on different shoot orders, it was shown that cones of similar size could occur in more than one kind of location. Cones of average size for the tree occurred most commonly on branches in the second internode.

Because of the manner in which cone size alters with cone position, there is a distinct upward and outward change in the proportions of potential seeds as compared with cones in the tree. Upper branches and outer shoots have a greater proportion of seeds than of cones, while lower branches and inner shoots have a lesser proportion. The differences amount to no more than three per cent. However, the value of cones from the upper part of the zone is underlined when one considers the quantities of seeds which can be involved - tree 1 bore more than 100,000 seeds in each seed year. On many trees uppermost cones had an effective size twice that of lowermost cones. It has been shown previously for other species that cones of the smallest size may contain only about half as many seeds or potential seeds as cones of the largest size (e.g. Eliason and Heit, 1940; Lyons, 1956). Simak, (1953b) and Sarvas (1962) showed this to be the case on single trees of Pinus sylvestris.

Since there is no uniformity in the between-tree numbers of potential seeds per cone, trees bearing similar numbers of cones (within years or between years) may produce very different numbers of seeds. Thus, in seeking for trees for use in seed procurement, both cone bearing and effective cone size must be considered. Both are under basic genetic control, but the former appears to be influenced to a great extent by tree growth conditions which affect the morphological development at the top of the crown. The effective cone size will also be affected by morphological development as it affects cone distribution. This is related to some extent to cone numbers, but other unknown factors are also influential.

The mean seed weight per cone was positively related to effective cone size on single trees. Thus larger cones produced not only more seeds, but these seeds were, on average, heavier seeds than from smaller cones. This agrees with the findings of Perry and Coover (1933), Eliason and Heit (1940) and Wright (1945) for various Pinus species, and with those of Ching (1960) for Abies grandis. Simak and Gustafsson (1954) found seed weight per cone in Pinus sylvestris to increase with rising cone weight and falling seed number (see also, Simak, 1953b; 1961; Ehrenberg et al., 1955). Thus with cones of similar weight, those with fewer seeds had heavier seeds. However, seed weight per cone was influenced more by cone weight than by seed number. Seed weight per cone was not analysed in relation to cone weight or cone length in the current study, since these measures of cone size vary more than numbers of scales and thus do not express intrinsic cone size as well as the latter. However, it is possible that a similar situation to that in Pinus sylvestris holds in balsam fir. Simak and Gustafsson (1954) found higher seed weights per cone, on the average, for cones on grafts than for cones on mother trees. Presumably the growing conditions on the grafts were better than on the natural trees and so cones were able to develop more strongly. Differential development of cones of similar scale number may result from varying conditions of, say, aspect on balsam fir, resulting in variation in cone weight and in seed weight, just as cone length and weight were found to be less in a better seed year when adjusted for differences in numbers of scales (Table 4.23). Clearly, environmentally induced differences such as these require investigation in balsam fir[1]; the results would add appreciably to the intrinsic morphological relationships reported here.

Some of the greater mean seed weight per cone in the upper part of the crown is explained by a lesser frequency of empty seeds in such cones, as has been found for Pinus sylvestris (Eliason and Heit, 1940; Simak, 1961; Sarvas, 1962). In P. sylvestris, however, poorly pollinated cones commonly drop soon after the flowering period (Dengler, 1932; Plym Forshell, 1953; Sarvas, 1962), and Sarvas (1962) has shown that poorly pollinated large cones drop more readily than small ones. Thus small cones retained tend to have more non-pollinated ovules than larger retained cones. In Pinus, however, non-pollinated ovules tend not to develop further and thus they do not become empty seeds. This is not the case

[1] In this regard, Myers and Bormann (1963) and Lester (1968) studied some aspects of cone morphology of balsam fir over wide sections of the range of the species. Their investigations confirmed the great between-tree variation in cone characters but were too broad in scope to shed light on the detailed relationships under discussion.

in balsam fir in which poorly pollinated strobili develop normally (Dogra (1966) for Abies pindrow) and non-pollinated ovules continue development and become as large as normally fertilized seeds and similar in appearance (unpublished data of the author, cf. Pohl (1942) for Abies alba). The empty seeds of Pinus sylvestris result from abortion of embryos at various stanges of development. Sarvas (1962) showed this to result primarily from self-fertilization which is more common lower in the crown because of greater overlapping of male and female strobili there than higher in the crown. Additional empty seeds in balsam fir result from the same cause (unpublished data of the author). Empty seeds in balsam fir thus correspond more with those of Picea abies (Dieckert, 1964; Sarvas, 1968) and Pseudotsuga menziesii (Orr-Ewing, 1957): they result from non-pollination, self-fertilization and possibly sib-fertilization.

Full and empty seeds of balsam fir differ little in weight (unpublished data of the author): some empty seeds from the central part of the productive region of the cone weigh more than full seeds from more extreme parts of the productive region. In this respect balsam fir differs from Picea abies and Pseudotsuga menziesii in which the empty seeds weigh less than half the weight of full seeds (Baldwin, 1942; Dieckert, 1964). Balsam fir ovules which are not pollinated, or seeds in which embryos abort early, develop thick, hard layers of tissue inside the testa. Pohl (1942) described how a similar hard layer of stone cells develops from the nucellar tissues in empty seeds of Abies alba and postulated that lack of pressure from a developing embryo and endosperm allowed for this development. The closeness in weight of full and empty seeds makes it difficult to separate the two and probably accounts for the low soundness and germination values given for Abies species (Anon. 1948). This appears more logical than the suggestion of Roe (1948a) that persistent wing bases were responsible since these remain also on sound seed.

No explanation can be given for the finding that a greater proportion of insect-infested seeds occur in smaller (lower-situated) cones than in larger cones. The increase in full seed values in the best seed year corresponds with findings of many others (e.g. Baldwin, 1942; Sarvas, 1962; 1968; Andersson, 1965).

6.4 VEGETATIVE AND REPRODUCTIVE GROWTH IN RELATION TO BIENNIAL SEED PRODUCTION

The initiation of lateral buds in balsam fir has been shown to be similar to that of lateral buds in *Pseudotsuga menziesii* (Owens and Smith, 1964; Owens, 1969). Further in both species development may cease during the cataphyll-producing stage (see also, Silen, 1967). This has recently been shown to be the case also in *Abies grandis* and *A. lasiocarpa* by Eis (1970). As in *Pseudotsuga menziesii* (Silen, 1967; Owens, 1969), latent buds of balsam fir can develop, after one or two seasons, vegetatively, if forced to do so by removal of developed buds.

Development of lateral buds into male or female strobili is strongly influenced by position in the crown and also by position on the shoot in balsam fir and in other *Abies* species (Debazac, 1965; Eis, 1970). There is a somewhat similar situation in *Pseudotsuga* (and also *Picea* (Tirén, 1935; Debazac, 1965; Eis, 1967)), but the zonation in the crown is not nearly as clear and positional differences on shoots are proximal (male) to distal (female) (Allen, 1941; Debazac, 1965; Baradat, 1967; Owens, 1969) rather than upper (female or vegetative) to lower (male) as in *Abies*. However, there is a tendency in balsam fir for vegetative buds to be distal and female buds to be proximal (cf. Debazac, 1965).

Differentiation of microsporangiate and megasporangiate buds in these three genera are very similar, beginning at about the time of cessation of shoot elongation and continuing into the fall. Occasional development of male and female buds in atypical positions has been described in this work for balsam fir. Eis (1970) found similar occurrences in _Abies grandis_ and _A. lasiocarpa_, but did not observe strobili in terminal or subterminal positions. However, Debazac (1965) observed male strobili in terminal positions in both _A. nephrolepis_ Maxim. and _A. koreana_ Wils. Both Eis (1970) and Schooley (1967) (on balsam fir) found bisexual and megasporangiate strobili below the normal female zone in normal male positions on the shoot. Transitional vegetative to female[1] and proliferating female cones were also observed by Eis (1970). Thus the range of abnormal-strobilus production and production of strobili in atypical positions in _Abies_ is great. This emphasizes the fact that any bud may be influenced to differentiate in any way (cf. Longman, 1961) and once differentiation has begun, the direction of this differentiation may be altered.

When cones are borne, shoot lengths are shorter (cf. Morris (1951) for balsam fir and Tappeiner (1969) for _Pseudotsuga menziesii_) and since numbers of terminal and subterminal buds (together) are related to shoot length ($\hat{Y} = a + b \log X$) these are fewer in a cone-bearing year. However, in a cone-bearing year, numbers of terminal shoots are fewer on cone-bearing branches. The presence of cone buds and developing cones therefore causes failure of development of some terminal (subterminal) buds, as well as reduction in numbers of needle primordia (Morris, 1951).

Numbers of upper lateral buds initiated are linearly related to shoot length, but in cone-bearing years shorter shoots produce fewer, and longer shoots more buds than shoots of comparable length in a non-cone-bearing year. This is thought to be a consequence of position: positionally more vigorous shoots have a capacity to initiate more buds than positionally less vigorous shoots of

[1] One such transitional cone was produced on tree 12 in 1970.

similar length. This appears to parallel the finding of Little (1970) that despite correlation between bud length and shoot length, buds of the same length but situated on different orders produce shoots of different length, longer shoots arising on higher orders. Little (1970) associated this with greater bud diameter in the more vigorous positions, indicating greater vascular production. Unfortunately, shoot diameters were not measured in the current study, but it seems likely that the positionally more vigorous shoots, would have greater diameter than shoots of the same length situated lower in the crown.

Another factor which plays a part here is the nature of the buds produced. Generally, when cones are borne no buds become female. In the upper part of the zone, where total bud numbers tend to remain uniform, their place is taken by vegetative and lateral buds. In the lower part of the zone the numbers of buds initiated are fewer, on many shoots being nil, but on bud-bearing shoots most buds remain latent. Eis (1970) found that the numbers of lateral buds produced in the female zones of _Abies grandis_ and _A. lasiocarpa_ were fairly uniform between years. When female buds formed, the numbers of both vegetative and latent buds decreased. His data were based on terminal shoots only, and thus measured effects only on vigorous shoots. The results compare well with those for the upper part of the zone in the current study. This is the part of the zone of greatest vigour, involving whorls I and II and internode I and thus consisting mostly of shoots of order 8. Eis's data fail to show the very distinct effects of cone-bearing on shoots of lesser vigour, such as on those in the lower part of the zone in the current study.

Owens (1969) counted numbers of buds initiated on distal-most secondary shoots on side twigs of branches at three locations on the crowns of _Pseudotsuga_ menziesii trees and found no significant differences between a flowering and a non-flowering year. However, his data show consistently fewer buds initiated in the flowering year and it seems likely that larger samples might have shown a significant difference. In the non-flowering year, flower buds (male and female) took the places of some vegetative and some lateral buds. Owens (1969), as did Eis (1970), considered shoots of a single category only, and thus possibly overlooked effects of cone bearing on weaker shoots. However, Owens (1969), Eis (1970) and Silen (1967) have each stressed the importance of latent buds in relation to cone bearing. This is fully borne out by the results of the current study, but cone bearing has also been found to have a marked effect on numbers of buds initiated. Reductions in shoot length play a major role here, but other factors are also involved.

The reduction in numbers of shoots formed in balsam fir in a flowering year (Morris, 1951) is thus the result, in the female zone, of some non-development of terminal and subterminal buds and of some replacement of vegetative buds by female strobili in the more vigorous parts of the zone and possibly of some replacement of vegetative buds by latent buds in the less vigorous parts of the zone. In a flowering year, because of shoot-length reductions, fewer buds are initiated, but proportionately more of the subterminal and terminal buds develop fully, and proportionately more of the upper lateral buds develop vegetatively. However, it seems that, since there was a consistent decrease in the numbers of shoots produced annually throughout the period of study in the female zones of the sample trees, the shoot-number reductions in flowering years are not always made up in non-flowering years. In fact, there appears to have been a cumulative negative effect of the three seed years on numbers of branches produced.

Undoubtedly, on the sample trees, some of the reduction in shoot numbers with the years has been occasioned by shoot breakage of an unnatural type (a result of wire cages, proximity of the towers and frequent handling), but natural breakage has also occurred. Some of the latter, e.g. cutting of cone-bearing shoots by squirrels, is directly associated with seed bearing. It is clear, however, that breakage has played only a partial role in the decreasing shoot numbers, since the very definite decreases in whorl-branch production and internode-branch production (Table 5.5) were a major factor.

If failure to make up flowering-year-shoot losses proves to be a general phenomenon then it will provide a clear indication that, as suggested earlier, the size of the female zone (in terms of numbers of shoots) does decrease with age after the period of maximum cone production, provided biennial bearing continues. On the other hand, sporadic heavy bearing on younger or more vigorous trees, though causing an immediate reduction in production of shoots, is such that shoot numbers will be able to build up during periods of little or no cone bearing. A somewhat similar situation may hold with more regularly bearing more vigorous trees: a period of biennial bearing may be followed by a period of little bearing during which vegetative growth is relatively greater. This would result in an additional cycle of seed bearing being superimposed on the usual biennial cycle. Past flowering records (Fig. 2.3) show a fairly consistent lack of heavy bearing on the sample trees in the late 1950's which lends support to this. In addition, most of the sample trees produced maximum numbers of whorl branches several years before.

There are two other possible explanations, or contributing causes, for the decrease in shoot numbers during the period of study. The first is that there was a slow build up in spruce budworm numbers from very small in 1964 to epidemic in 1969 and 1970. However, all budworms encountered during the course of this study in the female zones of the sample trees were destroyed, at first by hand, but in 1969 a two-per-cent solution of Phosphamidon was sprayed onto the trees. Nevertheless,some new foliage was consumed, but very few shoots were lost to this cause prior to 1970. Damage to new foliage in the lower crown parts must have occurred, but did not to a noticeable extent until 1969. It is impossible to estimate the degree of lessening in vigour and in ability to produce new shoots that was brought about by the budworm, but it is thought to have been small.

The second possible explanation is that there was a decrease in the qualities of the growing seasons during the period of study. Such a decrease might have an effect on tree vigour and hence on the production of shoots. Apart from some tendency for cooler than normal weather in late August and September in several years, there is no obvious evidence in climatological records that indicates unusual growing season qualities. Of course, the combinations of climatic occurrences which might bring about a lessening in shoot production are unknown, but it seems that climate was probably not a major contributor.

Clearly, the shoot-number reductions in flowering years do not have as great an effect, nor as direct an effect, in balsam fir as do the shoot reductions in Picea (Tirén, 1935). They do, however, play a significant role in reducing the cone-production capacity, which, with biennial bearing appears to be largely responsible for waning cone production in overmature trees.

It is abundantly clear that cone bearing and seed bearing are affected by intrinsic factors operating in the upper part of the tree's crown. These factors are expressed in morphological character of branching, of individual buds and shoots and of cones, as well as numbers of the different structures. The morphological expression is symptomatic of physiological variation, much of which is associated with relative vigour and hence with apical dominance or correlative inhibition.

Much evidence has been presented which shows that vigour of branch growth decreases both down the tree and down individual branches (cf. Zimmermann, 1936; Friesner, 1943; Prat, 1945; Friesner and Jones, 1952; Szymański and Szczerbiński, 1955; Duff and Nolan, 1958; Wareing, 1958; Kozlowski and Ward, 1961; Fraser, 1962; 1966; Moorby and Wareing, 1963; Tepper, 1963; Debazac, 1965; Owston, 1969; Rangnekar et al., 1969). The author indicated (Powell, 1970) that bud length in balsam fir was correlated with shoot length. This has also been found to be the case in other species (Szymański and Szczerbiński, 1955; Hanover, 1963; Rehfeldt and Lester, 1966; Clements, 1970; Little, 1970), but only for relatively young trees. Both size of buds and size of shoots have been positively correlated with auxin content in other conifers (e.g.Zimmermann, 1936; Onaka, 1950; Westing, 1962), and Kopcewicz (1968) found terminal buds of Pinus sylvestris to contain more gibberellins than lateral buds. Thus the larger buds and longer shoots of the upper and outer parts of the female zone contain (or produce) more growth regulators than the smaller buds and shorter shoots in the lower and inner parts of the zone. The distribution of nutrients between the apices within any one branch system appears to be governed by the sizes or position of the apices, and hence their auxin or other growth-regulator content (Gregory and Veale, 1957; Kozlowski and Winget, 1964; Seth and Wareing, 1964; Smith and Wareing, 1966; Little, 1970). In this manner apical dominance is maintained. Moorby and Wareing (1963) and Little (1970) have demonstrated the compensatory effects of removal of shoots of different kinds from a branch system.

Wareing (1958) and Moorby and Wareing (1963) showed how the decrease in vigour within the branch system was linked with ageing. Ageing, clearly cannot refer to the ages of the buds or shoots themselves, but to the number of years which have passed since the branch system in question was first formed. Wareing (1958) linked ageing in Pinus sylvestris to ability to produce male or female strobili. Female strobili are produced on leading shoots of major branches and strong laterals (see also Prat, 1945; Gal'pern, 1949; Yunovidov, 1950; Melchior and Heitmüller, 1961). Male strobili are first borne on shoots of low morphological category in the basal region of low branches. In subsequent years male flowers occur on shoots of higher morphological category on the same branches, and on shoots of low category on higher branches. A branch is therefore first female, later both female and male, but on vigorous and less vigorous shoots respectively, and later still possibly all male (cf. Prat, 1945). A similar situation has been demonstrated for balsam fir, but only rarely do female and male strobili occur on the same branch. For the size of trees studied, a branch produces female buds in either its first year, its third year and fifth year, or its second and its fourth year (assuming biennial bearing and a zone size of five whorls). Thereafter, the branch produces male buds, but rarely at first on its leading shoot. Thus, for a given size of tree, a branch has the capacity to form female buds on the upper sides of its shoots for about five years. Then, abruptly, buds cease to be formed on the upper sides of its shoots and others form in much greater numbers on the lower sides. However, with ageing before this stage, the weakest shoots cease to form lateral buds on their upper sides.

The changeover from femaleness to maleness is probably controlled by growth regulators. The reduction in shoot growth which occurs down the female zone is continued down into the male zone (cf. Fraser et al., 1964; Fraser and McGuire, 1969 for Picea). Thus, a decrease in growth-regulator content from the female to the male zone is indicated. Hashizume's (1969) data lend support to this. He found female and male strobili of several conifers (not Abies) to be formed on shoots with relatively high and relatively low auxin content respectively. Kopcewicz (1968) found gibberellin content in shoots to decrease downwards from the apex of the tree. Further support is provided by the fact that there is a gradual change in the angle which branches as a whole, and individual shoots, assume. Branches in the upper part of the female zone are angled upwards; as branches age they become more horizontal and bear many horizontal or even drooping shoots (cf. Moorby and Wareing, 1963). Kato and Ito (1962) showed that, in apple, terminal buds of horizontal and drooping shoots produce less auxin and gibberellin than do those of vertical shoots. This would appear to be the case in Larix leptolepis also, since Longman (1961) and Longman et al. (1965) found that when branches were treated so that they assumed a horizontal or drooping position, shoot growth was much reduced (as in apple (Wareing and Nasr, 1961)).

It is not, however, suggested that branch angle alone is responsible for the change from female to male, because each shoot, as it develops tends to grow for a while with an upward curvature. General observations indicate that the final angle assumed by the shoot, which itself tends then to be straight, corresponds with that of the bud. Longman (1961) and Longman et al. (1965) found that male buds of Larix leptolepis occur mainly on the lower sides of horizontal shoots, but on all sides of drooping shoots. When horizontal shoots were inverted during the bud-initiation stage initiated buds on the physically lower sides, but morphologically upper sides, became male, while vegetative buds differentiated on the opposite sides. They suggested that a flower-inducing substance was therefore distributed gravitationally on the lower sides of the horizontal shoots and downward into drooping shoots. This would appear to be the case also in male shoots of balsam fir, except that since most male shoots do not form upper lateral buds, drooping shoots do not bear male buds on all sides. Male shoots have been observed with buds on the upper sides at their bases, and on a few more vigorous shoots nearer their apices. It is only on the former that buds have developed into male buds, however, and these not normally on drooping shoots. This indicates, perhaps, a stronger stimulus nearer the base. (Male buds in atypical positions in the female zone cannot be explained by the foregoing.)

Gravitational distribution of a flower-inducing substance does not explain bud initiation on different sides of shoots of different vigour, or on branches of different age. However, it is logical to assume that a bud-inducing substance could function in a similar manner. Indeed, the fact that shoots show an upward curvature as they grow demonstrates the probable occurrence of a classical effect of unequal distribution of auxin in the upper and lower parts of the shoot. It is not known whether curvature exists in the telescoped shoot within the bud when new-bud positions become evident histochemically (Owens, 1969), but it is evident at the time of flushing when the bud primordia are microscopically evident. At that time the needles on the lower side of the shoot are longer than those on the upper side, indicating greater growth promotion on the lower side. Since upper and lower buds are initiated at the same time (but rarely on the same shoots), it would appear that upper-bud initiation is associated with relatively low auxin levels in shoots having a relatively high auxin content, while lower-bud initiation is associated with relatively high auxin levels in shoots having a relatively low auxin content. Clearly, investigation of the growth regulators in shoots in unopened buds would be informative.

Since the shoots tend to straighten by the end of the period of elongation, there is obviously a redistribution of auxin across the shoot during the cataphyll-producing period. General observations indicate that the point of curvature, and hence the straightening of the shoot, migrates along the shoot as elongation proceeds. It seems possible that a progressive redistribution of auxin (or other growth regulators) across and along the shoot may influence the distribution of buds of different kinds along the shoot. For example, the last point of increase in auxin level along the upper side of the shoot, according to this theory, would be the part near the apex where vegetative buds commonly differentiate. If high auxin levels are associated with vegetative-bud differentiation, as they are with vegetative bud growth, then this explanation appears plausible. Lateral vegetative bud differentiation, and, of course, subterminal and terminal bud differentiation, occur each year: the foregoing theory allows for this and suggests that the degree of development of lateral buds in the cataphyllary stage, and whether or not subsequent floral differentiation occurs is contingent upon other factors. The later occurrence of relatively high levels in the upper side of the shoot would be consistent with the earlier-mentioned idea that female buds are associated with higher auxin levels (see also Owens, 1969).

Growth-regulator influence is again shown by the effects of removal of the tree's leading shoot. If a new leader is established by vigorous upward growth of a branch in the uppermost remaining part of the tree (cf. Little, 1970), then female-bud differentiation continues. If, on the other hand, no apically dominant shoot develops and a flat top is formed on the tree, this does not prevent the continual rise in the upper limits of the male zone, and in a few years the tree becomes entirely male. This indicates that the male-bearing capacity of the branch is conditioned by age coupled with poor vigour and that female bearing is associated with great vigour and hence with high auxin content (see also Melchior and Heitmüller, 1961; Melchoir, 1962; Debazac, 1965). If, in time, a branch does develop apical dominance and grows appreciably more vigorously than other branches, then it redevelops a capacity to form female buds, but only on the new vigorous shoots. This is consistent with the finding of Yunovidov (1950) for Pinus sylvestris that weaker, entirely male branches could develop female-bearing shoots if the conditions of growth (in this case particularly illumination) became much better.

In order to assess how the study of morphological differences in the female zone of the tree between cone-bearing and non-cone-bearing years assists in explaining periodicity of flower production, it is necessary to compare the different forms of growth which occur on the tree on a uniform time scale. Figure 6.1, which was derived from observations made in this and associated studies (e.g. Powell, 1970), provides a ready means of comparison for balsam fir. The indicated dates for different events are average, and of course, the actual dates vary according to the nature of the season. It is possible that the periods and rates of growth, other things being equal, of similar events in cone-bearing

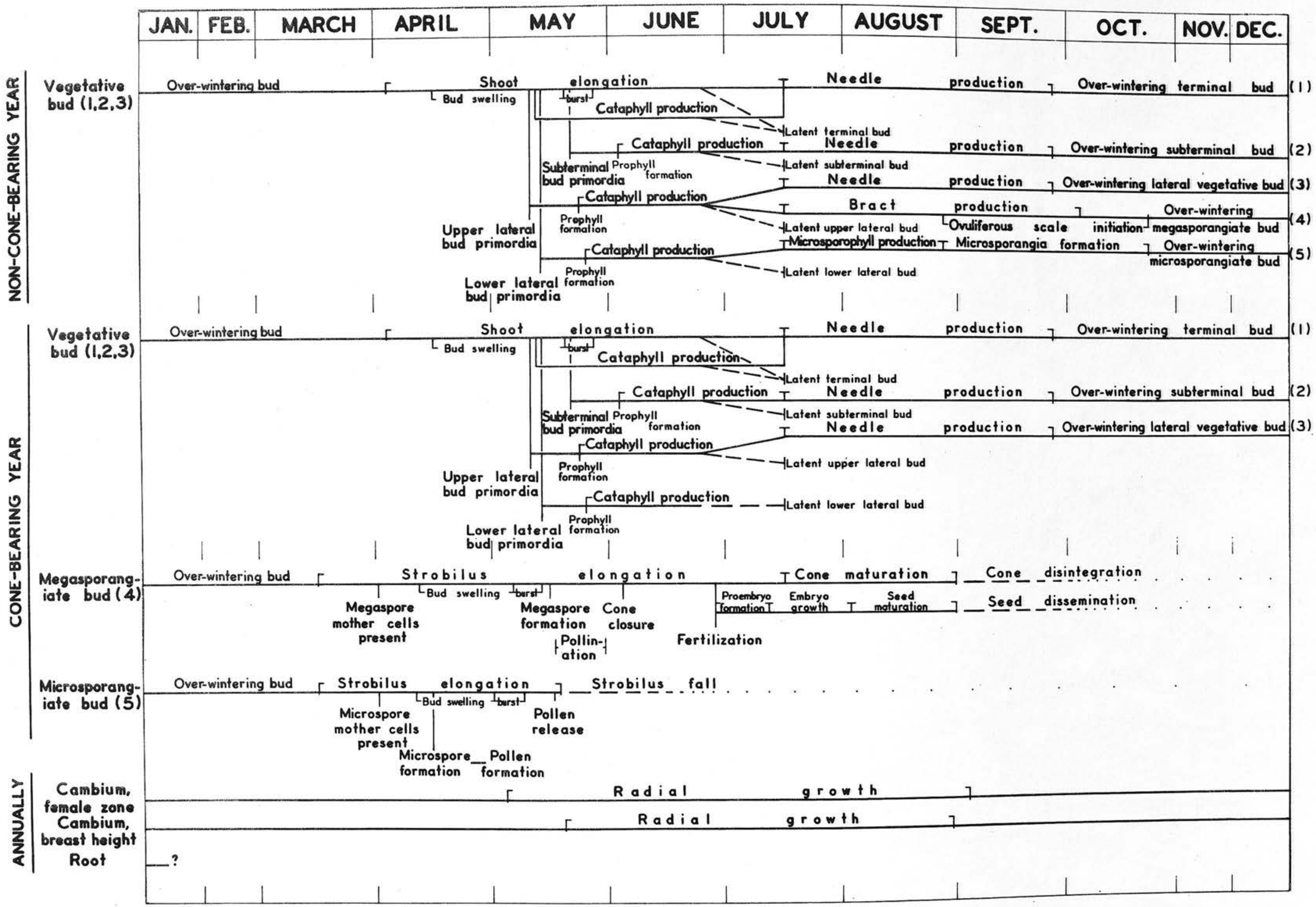

Figure 6.1. Growth cycles in cone-bearing and non-cone-bearing years in balsam fir.

and non-cone-bearing years vary. However, the accumulated data on growth periods and growth rate have not yet been analysed in those terms and the periods are shown equal. It is possible that shoots in the male zone grow for a shorter period than shoots in the female zone in any given year. An earlier cessation of growth has been shown for lower-situated shoots in other species (Friesner, 1943; Friesner and Jones, 1952; Fielding, 1955; Duff and Nolan, 1958; Fraser, 1962; 1966).

The only major, and of course obvious, difference between the two kinds of years is the presence of the male and female strobili in a cone-bearing year. This, therefore, appears to be a controlling factor in the biennial bearing of this species. The importance of this is emphasized when the timing of early events in the growing season is considered. By the time the vegetative buds burst in a cone-bearing year, the male strobili have developed to maturity and are releasing their pollen. The pollen constitutes about half of the dry weight of the strobili (Powell, 1970), and presumably a greater percentage of the nutrient content. The average dry weight, after release of the pollen, of male strobili on heavily bearing trees (1, 2 and 5) in 1968 was about 450 grams (unpublished data of the author). The female strobili have also grown at an exceedingly rapid rate to a length of about three centimeters and a diameter of almost a centimeter (Powell, 1970).

This great amount of growth requires carbohydrates and mineral elements for the production of structural components. At the same time, since growth is rapid, respiration will be intense (cf. Ching and Ching, 1962) and will consume large amounts of carbohydrates at a time when photosynthesis is relatively low. In addition, bud swelling occurs in the vegetative buds: this will also draw on the available supplies of carbohydrates and nutrients. Kozlowski and Gentile (1958) showed that rapid increases occurred in respiration of Pinus strobus buds as they began to swell. When buds of Pinus sylvestris were expanding, photosynthesis only balanced respiratory losses and old needles lost dry weight to the same extent as new shoots gained dry weight (Rutter, 1957). In balsam fir, Clark (1961) reported that more carbon dioxide was released by respiration than used in photosynthesis in the early growth of new needles. More recently Clark[1] has shown a striking negative carbon dioxide exchange in one-year-old shoots (whorl I) in the apex of the crown of ten-metre-tall balsam fir trees. In 1969 this lasted from early April until mid June when photosynthesis used more carbon dioxide than was released by respiration. The maximum negative values, which almost equalled the maximum positive values of July and August, occurred at about the time of bud bursting. No cones occurred on the shoots used in 1969, a non-flowering year. It is postulated that negative values may occur over a longer period and that a longer period of greater negative values may occur when cones are developing on the shoots. Figure 6.1 also shows that cambial activity in the main stem of the female zone begins in early May. This too, will require carbohydrates and nutrients.

It is clear that there is extra and earlier drain on the stored resources and current photosynthesis of the tree when cones are developing. Studies in other species have shown that one-year-old needles of Pinus support the growth and respiration needs of the new shoot to a large degree (O'Niel, 1962; Kozlowski and Winget, 1964; Larson, 1964; Clausen and Kozlowski, 1967; Krueger, 1967; Dickmann and Kozlowski, 1968; Gordon and Larson, 1968; 1970; Ursino et al., 1968; Rangnekar et al., 1969). Clark (1961) in balsam fir and Picea glauca determined

[1] Clark, J. 1969. Personal communication.

that one-year-old needles were the most efficient photosynthetically in the spring. This would appear to be the case in Pinus also since Wood and Bachelard (1969) found chlorophyll concentrations to be greatest in one-year-old (second-season) needles in Pinus radiata.

The one-year-old needles also appear to be the main source of resources for the developing strobili, especially since they occur on the same shoots. This was suggested in the case of Pseudotsuga menziesii by Owens (1969) and confirmed for Pinus resinosa by Dickmann and Kozlowski (1968). It must be recalled, however, that in Pinus it is cones in their second year that occur at the apices of a shoot carrying one-year-old needles (in their second year of growth). The first-year cones develop, in Pinus resinosa, at the apex of the current year's shoot and remain small and thus their requirements are small. Dickmann and Kozlowski (1968) found that they mobilized only very small amounts of carbohydrates from older needles: the current-year needles contributed negligible amounts. The second-season cones appeared to have first call on available carbohydrates. They mobilized almost three times as much carbohydrates from old needles as was mobilized by new shoots. They are thus strong carbohydrate sinks, and like apples (Hansen, 1967), appear to draw most of their needs from closely situated leaves.

High nitrogen contents, related to high physiological activity or high proportions of meristematic tissues, have been reported for Pinus species at the time of pollination (Katsuta and Satoo, 1964; Kupila-Ahvenniemi, 1966; Dickmann and Kozlowski, 1969). Since losses of nitrogen, phosphorous and potassium have been reported from one-year-old shoots at the time new elongating shoots of Pseudotsuga menziesii were accumulating these elements (Krueger, 1967), it seems that one-year-old needles and shoots may supply a considerable portion of the mobile-element needs of the developing strobili. It is, however, conceivable that with greater translocation of photosynthates out of the one-year-old needles, they increase their rate of photosynthesis as has been found in leaves of apples (Mochizuki, 1962; Maggs, 1963; Hansen, 1967). However, Mochizuki (1962) determined that the increase was far below what was needed to supply the developing fruits and the other requirements of the tree: in a fruiting year, trunk expansion and root extension were much reduced (cf. Wilcox, 1937; Singh, 1948).

The balsam fir cone bracts are frequently pale green in colour (Powell, 1970) and thus contain some chlorophyll. However, since new needles of deeper colour have been shown to be inefficient in terms of net photosynthesis when young (Clark, 1961), it seems that any photosynthesis carried on by the bracts will contribute little to the developing cone.

While both bud initiation and early cataphyll formation occur in potential male-bud positions and potential female-bud positions in a cone-bearing year in the presence of developing strobili on subtending shoots, subsequent development of male buds occurs after the strobili have withered (Fig. 6.1). On female branches post-pollination growth of the female strobili continues and will require further amounts of carbohydrates and nutrients. Ching and Ching (1962) and Ching and Fang (1963) showed that developing cones of _Pseudotsuga menziesii_ mobilized considerable quantities of carbohydrates. For _Pinus thunbergii_ Parl., Katsuta and Satoo (1964) showed increases in nitrogen in second-year cones. Dickmann and Kozlowski (1968; 1969) determined that both carbohydrates and macronutrients moved into second-year _Pinus resinosa_ cones during the shoot-elongation period, and further, that the major source for the carbohydrates was the one-year-old needles.

The situation with regard to influences of developing strobili is, therefore, different for male shoots and for female shoots, at least during the later stages of shoot elongation. Nevertheless, it seems that both the male and female strobili, through preferential use of nutrient elements and carbohydrates, cause reductions in new shoot elongation and in the degree of development of buds that have been initiated on the shoots. It must be stressed here, that Morris (1951) found not only a decrease in shoot length in balsam fir in a cone-bearing year, but also a decrease in the numbers of needles per shoot. Thus, the presence of strobilus buds on the shoots in late summer adversely affected the number of needle primordia initiated. However, Morris (1951) found shoot length to be reduced to a greater extent than needle numbers, and the needles produced were shorter and weighed less in a cone-bearing year. His data therefore support the contention made here.

From the fact that the direct male-strobilus influence lasts only until vegetative bud break, or shortly thereafter, it seems that inhibition of cataphyll formation is sufficient to prevent male-flower-bud differentiation. Thus, when strobili are present, few initiated buds are able to develop the requisite complement of cataphylls, and hence, presumably, the apex will not have undergone appropriate changes in morphological and physiological condition to be able to respond to a stimulus to differentiate microsporophylls. This is consistent with the observation that most initiated buds in male positions which fail to develop in a cone-bearing year, do so during the early cataphyll-producing stage. It is possible that those that cease development at a later stage are influenced by a delayed inhibitory effect, by the continued presence of female strobili on the tree, or by lack of ability of the smaller needles on the shoots to support male bud development as well as vegetative bud development, radial growth and storage. However, on some trees some male buds do complete development in cone-bearing years, and in contrast, some buds fail to complete development in non-cone-bearing years. These occurrences are thought to be controlled by the general vigour of the tree and the apparent major influence of very local conditions on shoot development. For example, some shoots are subtended by older shoots bearing no strobili, others many; some subtending shoots bear one new shoot, others two or three.

In the case of female shoots, the competition for available supplies from the older shoot and needles by the developing strobili and the developing shoot, continues until shoot and strobilus elongation cease in mid July (Fig. 6.1). Even after this, some demand for carbohydrates and nutrients continues in the strobili since weight increase continues as the seeds develop (Powell, 1970, see also Ching and Ching, 1962; Ching and Fang, 1963; Katsuta and Satoo, 1964; Dickmann and Kozlowski, 1968; 1969). However, at about this time the photosynthetic efficiency of the new needles reaches a high level (Clark, 1961) and they become the prime suppliers for radial increase and respiration in the new shoot and for the development of the new terminal bud (Dickmann and Kozlowski, 1968; Gordon and Larson, 1968; 1970; Ursino et al., 1968). Presumably the development of the lateral buds is also supported at this time by the new needles. It seems then, that the developing female strobili maintain their influence on the growth of the new shoot until shoot elongation ends. Before this time, however, the new shoot will become progressively more self sufficient as far as the products of photosynthesis are concerned.

The presence of female strobili appears, therefore, to have a similar effect on new lateral-bud development as does the presence of male strobili, only the effect continues in a direct fashion for a longer period. This would account for early cessation of development of upper lateral buds. However, while this may explain the greater proportion of such latent buds in a cone-bearing year, it does not explain the presence of some latent buds in a non-cone-bearing year. Again, it seems that individual shoot character must be involved here.

The fact that decapitation influences latent buds on both male and female shoots to differentiate vegetatively in the following season suggests that some influential factors are hormonal in character. Normal development of a terminal vegetative bud appears to inhibit vegetative-bud differentiation in the lower lateral positions, but allows differentiation of male buds. In the upper lateral-bud positions either vegetative or female buds may develop. It seems probable that the maturing strobili produce a female-differentiation inhibitor or create conditions in the new shoot which severely limit the possibility of female-bud differentiation. It is noteworthy that more buds become latent in the proximal position, which is closer to the strobili, than in the distal position (where buds more frequently are vegetative). Little is known of the growth regulators in strobili, but auxin, gibberellin and kinin are associated with fruit growth, but not necessarily in the same fruit (Leopold, 1962; 1964). Luckwill (1963) made the tentative suggestion that fruits inhibit flower initiation because they produce relatively large quantities of growth-promoting substance. The same might be the case for cones: even when cone growth diminishes, auxin or other growth regulators may be produced in the developing seeds (cf. Leopold, 1962; 1964).

It is clear that when cones are absent from the tree, extra drain on the resources of the tree will not occur during the shoot-elongation period.

The fact that more resources are available is reflected in the greater shoot growth and also stem-diameter growth which occurs in non-cone-bearing years (e.g. Morris, 1951; Rohmeder, 1967). Thus, it is logical to expect a greater degree of lateral-bud development. Flower-bud differentiation appears to be more likely as strobili, a seemingly inhibitory influence, are not present. The differentiating buds will be supported in their development by both the new needles and, presumably the one-year-old needles, which in a cone-bearing year continue to supply the needs of the maturing cone. In the light of these findings, the biennial bearing of balsam fir is logically explained. Indeed, Owens (1969) found it difficult to explain why _Pseudotsuga menziesii_ did not bear cones abundantly every second year. However, as is plain from the foregoing, there are many aspects of the biennial bearing of balsam fir which require further investigation.

6.5. CONCLUSION

This study has shown that there are many factors of an intrinsic nature, which are expressed in morphological variation throughout the tree's crown and within specific parts of the crown, which have an effect on seed production in balsam fir. The variation within years is generally evident in terms of numbers and sizes of various structures. For most characters, it has been shown that the variation is gradual and thus explainable by the existence of gradients in physiological activity which are related to apical dominance. Morphological character of the female strobili tends to vary in a similar manner to that of the shoots in the same region of the crown. This has a clear influence on seed-bearing in different parts of the cone-bearing region and indicates that cones from more vigorous parts of the region have the greatest value in terms of both numbers and potential quality of the seed contained.

Striking changes in numbers and positions of lateral buds occur with the change from femaleness to maleness. Although these can be broadly associated with gradual changes in physiological activity, it is clear that a major change must also take place in some buds prior to lateral-bud initiation thus permitting later differentiation of male buds. Since the change in morphological expression is dramatic in a short space of crown, it may prove relatively easy to associate biochemical content with this change. The underlying cause, however, may prove to be more elusive, but it seems that investigations may be more rewarding on balsam fir than on many other species where comparable major changes are less distinct.

Successive-year variation in cone-bearing ability is conditioned largely by the presence or absence of developing strobili and their associated needs for nutrients and carbohydrates. Their influence is evident through observations of morphological differences, notably in shoot development and in lateral-bud development. As has recently been stated (Owens, 1969), "the basis for explaining any variation in a cyclic pattern of reproduction must begin with an understanding of the detailed vegetative growth cycle of the plant". This study has certainly shown this to be true in balsam fir, and it seems unfortunate that the early emphasis on morphological investigation in conifers given by Tirén (1935) was not followed up until recently. Clearly, balsam fir has an intrinsic inability to differentiate flower buds at a time when strobili occur on subtending shoots. Thus, a compensatory effect appears to exist between vegetative and reproductive forms of growth. This can be interpreted in terms of competition for growth requirements between meristematic apices situated in different positions.

Relative position also influences the likelihood of development and the mode of development of the various apices and the latter appears to have some influence on relative priority for use of available resources.

It seems obvious that because of the effect on vegetative growth in one year, heavy bearing will result in fewer possible locations for flower buds in the following year. Thus the next seed year is likely to be poorer, other things being equal. The reverse would appear to be true also. However, this intrinsic limit to cone bearing must also be affected by the nature of the growing-season environment in the years concerned. The fact that one complete whorl of branches and one complete internode of branches is formed at the top of the tree in the absence of strobili may have considerable influence also. Thus while intrinsic factors may preclude flower-bud formation in certain years, they also set a basic limit to flower-bud differentiation in others. The degree to which flowering occurs up to that limit depends on the duration or intensity of the particular combination of environmental conditions which permit or promote flowering.

In conclusion, it may be stated that the examination and identification of intrinsic morphological patterns assists in understanding factors which influence seed production on single trees in seed-bearing years and over periods of years. Further, the manner of influence becomes clearer when the seed-production process is considered along with the other growth processes which occur on the tree. Environmental influences, it seems, can act only in a modifying manner on the basic intrinsic patterns of growth. It is essential, therefore, to gain an understanding of these patterns of growth before major investigations of environmental influences are undertaken.

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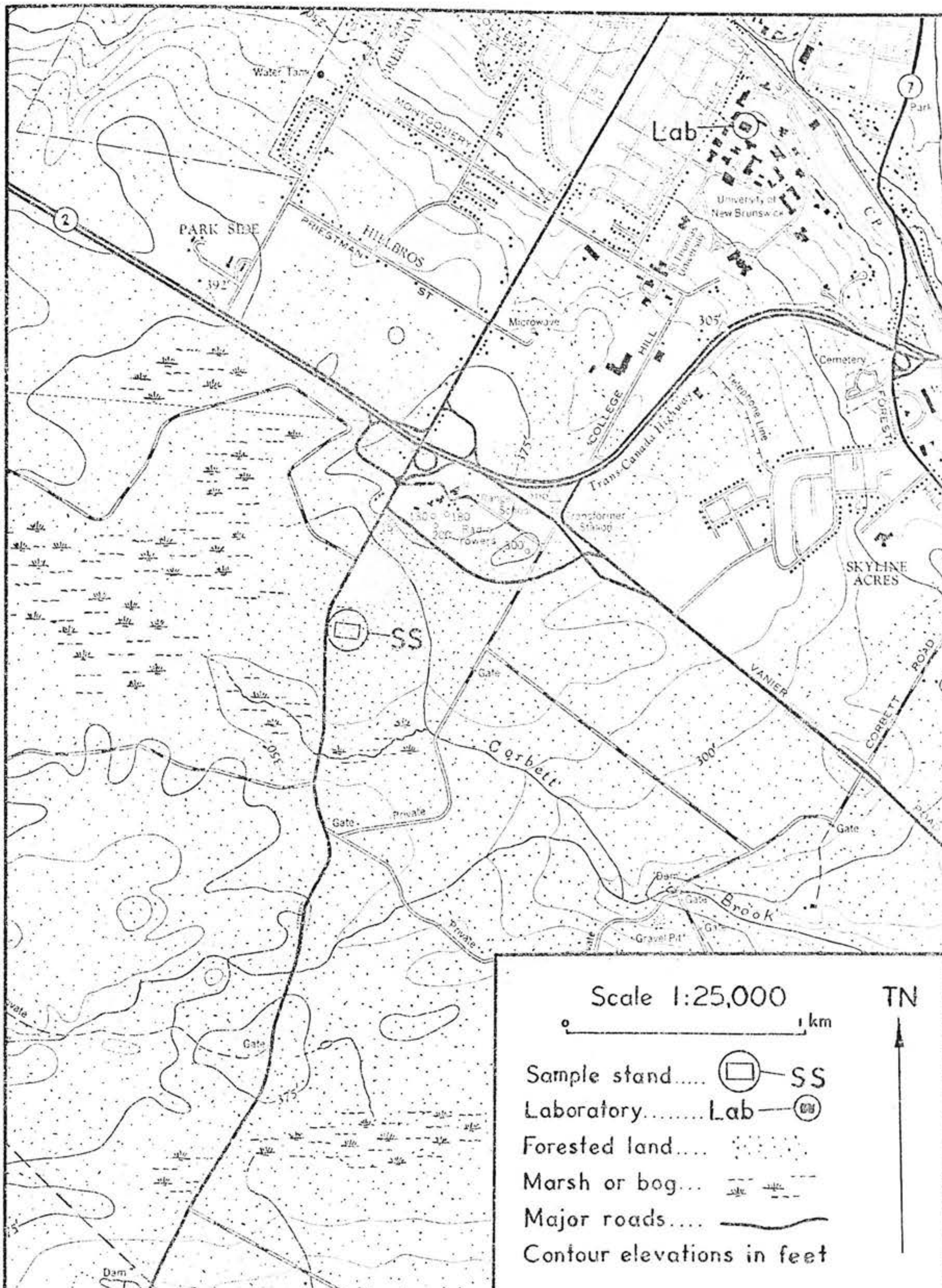
APPENDIX 1

LOCATION OF THE SAMPLE STAND AND OF THE LABORATORY WITHIN THE BOUNDARIES OF THE CITY OF FREDERICTON, NEW BRUNSWICK


Lab
University of New Brunswick
St. Thomas University
PARK SIDE
392'
HILLBROS
PRIESTMAN
ST
MONTGOMERY
Water Tank
Microwave
305'
Cemetery
FOREST
COLLEGE HILL
Trans-Canada Highway
Telephone Line
Park
CP
SKYLINE ACRES
SS
Gate
Corbett
Brook
300'
VANIER
CORBETT ROAD
Private
Dam
Gravel Pit
375'
Scale 1:25,000
0
1 km
TN
Sample stand..... SS
Laboratory........Lab
Forested land....
Marsh or bog...
Major roads....
Contour elevations in feet

APPENDIX 2. FREQUENCY OF OCCURRENCE OF SPECIES IN THE GROUND VEGETATION LAYER OF THE SAMPLE PLOT

Frequencies are based on 100 one-sixteenth-square metre, circular plots distributed randomly (by grid-reference points) over the plot.

Species	Frequency %
Abies balsamea (L.) Mill.	36
Acer rubrum L.	1
Clintonea borealis (Ait.) Raf.	2
Cornus canadensis L.	20
Dicranum scoparium Hedw.	37
Epigaea repens L.	2
Gaultheria hispidula (L.) Bigel.	1
Gaultheria procumbens L.	2
Kalmia angustifolia L.	1
Linnaea borealis L.	15
Lycopodium clavatum L.	2
Lycopodium obscurum L.	2
Maianthemum canadense Desf.	9
Osmunda cinnamomea L.	2
Pinus strobus L.	4
Pleurozium schreberi (B.S.G.) Mitt.	38
Polytrichum commune Hedw.	9
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw.	3
Thuja occidentalis L.	8
Trientalis borealis Raf.	1
Vaccinium myrtilloides Michx.	28

APPENDIX 3. SUMMARY OF DATA FOR THE DIFFERENT TREE-CHARACTER VARIABLES IN EACH OF THE THREE SEED YEARS

A. 1964 Seed year (199 trees)

Variable	Minimum	Mean	Maximum,	Standard deviation	Coefficient of variation (%)
DBH (cm)	4.6	9.17	21.7	3.79	41.3
H (m)	3.5	7.82	13.9	2.59	33.2
CL (m)	0.9	3.70	9.2	1.67	45.2
CW (m)	0.7	2.06	4.4	0.74	35.8
AGE (yrs)	18	40.1	69	11.8	29.4
LL64(dm)	0.1	1.61	3.5	0.87	53.8
LL65(dm)	0.1	1.76	4.5	0.94	53.6
LL66(dm)	0.1	1.53	4.5	0.90	58.6
LL67(dm)	0.1	1.74	4.5	1.02	58.8
LL68(dm)	0.1	1.72	4.5	1.12	65.5
LLx5(dm)	0.5	8.35	18.5	4.35	52.1
RW-4(cm)	0.016	0.0983	0.436	0.0636	64.7
RW-3(cm)	0.016	0.0920	0.332	0.0569	61.8
RW-2(cm)	0.008	0.0736	0.415	0.0567	77.0
RW-1(cm)	0.004	0.0719	0.473	0.0622	86.5
RWx2(cm)	0.016	0.1455	0.888	0.1158	79.6
RWx3(cm	0.032	0.2376	1.220	0.1676	70.6
RWx4(cm)	0.052	0.3358	1.552	0.2260	67.3
RWx8(cm)	0.100	0.6388	2.862	0.4253	66.6
CC	2	3.8	8	1.9	50.7
UCC	2	4.5	5	0.6	13.6
BCC	3	4.3	5	0.5	12.5
FCOL	1	2.1	4	0.8	37.4
MCOL[x]	2	4.9	7	1.2	25.3
CLPC (%)	18.99	47.064	81.42	12.554	26.7
CBA (m^2)	0.38	3.740	15.20	2.638	70.5
CVOL (m^3)	0.28	5.452	40.66	6.304	115.6
CSA (m^2)	2.04	13.611	58.57	10.187	74.8
DH (m^2)	0.18	0.804	3.02	0.592	73.7
D2 (m^2)	0.002	0.0098	0.047	0.0086	87.8
D2H (m^3)	0.008	0.0955	0.654	0.1138	119.1
CSSS	4.37	19.319	55.11	10.247	53.0
HCC	7.0	33.57	111.2	27.90	83.1
COCL	2	2.7	8	1.2	44.6

x Number of trees = 75.

Continued . . .

Appendix 3. Continued

B. 1966 Seed Year (199 trees)

Variable	Minimum	Mean	Maximum	Standard deviation	Coefficient of variation (%)
DBH (cm)	5.0	9.50	22.3	3.94	41.4
H (m)	3.6	8.16	14.3	2.65	32.5
CL (m)	1.2	4.03	9.7	1.75	43.4
CW (m)	0.8	2.16	4.5	0.74	34.1
AGE (yrs)	20	42.1	71	11.8	28.0
LL64 (dm)	0.1	1.61	3.5	0.87	53.8
LL65 (dm)	0.1	1.76	4.5	0.94	53.6
LL66 (dm)	0.1	1.53	4.5	0.90	58.6
LL67 (dm)	0.1	1.74	4.5	1.02	58.8
LL68 (dm)	0.1	1.72	4.5	1.12	65.5
LLx5 (dm)	0.5	8.35	18.5	4.35	52.1
RW-4 (cm)	0.008	0.0736	0.415	0.0567	77.0
RW-3 (cm)	0.004	0.0719	0.473	0.0622	86.5
RW-2 (cm)	0.008	0.0827	0.365	0.0640	77.3
RW-1 (cm)	0.008	0.0827	0.423	0.0613	74.1
RWx2 (cm)	0.020	0.1655	0.788	0.1232	74.5
RWx3 (cm)	0.032	0.2374	1.261	0.1805	76.0
RWx4 (cm)	0.044	0.3110	1.676	0.2316	74.5
RWx8 (cm)	0.100	0.6388	2.862	0.4253	66.6
CC	2	3.8	8	1.9	50.7
UCC	2	4.5	5	0.6	13.6
BCC	3	4.3	5	0.5	12.5
FCOL	1	2.1	4	0.8	37.4
MCOL[x]	2	4.9	7	1.2	25.3
CLPC (%)	18.99	49.239	82.20	12.326	25.0
CBA (m^2)	0.50	4.071	15.90	2.751	67.6
CVOL (m^2)	0.39	6.388	44.60	7.018	109.9
CSA (m^2)	2.48	15.401	62.69	10.978	71.3
DH (m^2)	0.20	0.866	3.20	0.630	72.8
D2 (m^2)	0.002	0.0106	0.050	0.0092	87.5
D2H (m^3)	0.010	0.1064	0.711	0.1248	117.4
CSSS	5.01	20.363	57.52	10.270	50.4
HCC	7.2	34.94	114.4	28.73	82.2
COCL	2	3.8	8	1.6	42.2

[x] Number of trees = 75.

Continued . . .

Appendix 3. Continued

C. 1968 Seed Year (199 trees)

Variable	Minimum	Mean	Maximum	Standard deviation	Coefficient of variation (%)
DBH (cm)	5.1	9.78	22.8	4.04	41.3
H (m)	3.9	8.48	14.7	2.70	31.8
CL (m)	1.2	4.28	10.0	1.80	42.1
CW (m)	0.9	2.26	4.6	0.74	32.6
AGE (yrs)	22	44.1	73	11.8	26.8
LL64 (dm)	0.1	1.61	3.5	0.87	53.8
LL65 (dm)	0.1	1.76	4.5	0.94	53.6
LL66 (dm)	0.1	1.53	4.5	0.90	58.6
LL67 (dm)	0.1	1.74	4.5	1.02	58.8
LL68 (dm)	0.1	1.72	4.5	1.12	65.5
LLx5 (dm)	0.5	8.35	18.5	4.35	52.1
RW-4 (cm)	0.008	0.0827	0.365	0.0640	77.3
RW-3 (cm)	0.008	0.0827	0.423	0.0613	74.1
RW-2 (cm)	0.004	0.0722	0.398	0.0573	79.4
RW-1 (cm)	0.004	0.0653	0.224	0.0422	64.7
RWx2 (cm)	0.012	0.1375	0.522	0.0947	68.9
RWx3 (cm)	0.020	0.2202	0.945	0.1523	69.2
RWx4 (cm)	0.044	0.3030	1.310	0.2130	70.3
RWx8 (cm)	0.100	0.6388	2.862	0.4253	66.6
CC	2	3.8	8	1.9	50.7
UCC	2	4.5	5	0.6	13.6
BCC	3	4.3	5	0.5	12.5
FCOL	1	2.1	4	0.8	37.4
MCOL[x]	2	4.9	7	1.2	25.3
CLPC (%)	18.99	50.220	81.97	12.036	24.0
CBA (m^2)	0.64	4.417	16.62	2.864	64.8
CVOL (m^2)	0.48	7.284	47.71	7.649	105.0
CSA (m^2)	2.76	16.988	65.58	11.614	68.4
DH (m^2)	0.20	0.924	0.34	0.662	71.6
D2 (m^2)	0.003	0.0112	0.052	0.0097	86.8
D2H (m^3)	0.010	0.1164	0.764	0.1345	115.6
CSSS	5.45	21.017	57.73	10.04	47.8
HCC	7.8	36.25	117.6	29.47	81.3
COCL	2	2.6	8	1.1	40.5

[x] Number of trees = 75.

APPENDIX 4. CONSTANT TERMS AND REGRESSION COEFFICIENTS FOR RELATIONSHIPS BETWEEN CONE CLASS AND TREE-CHARACTER VARIABLES FOR 199 TREES IN EACH OF THREE SEED YEARS

	Constant term (a)			Regression coefficient (b)			Test of differences between regression coefficients		
	1964	1966	1968	1964	1966	1968	1964 - 66	1966 - 68	1964 - 68
DBH	0.7671	0.8938	0.9182	0.2073	0.3085	0.1759	**	**	NS
H	0.2179	-0.2346	0.3742	0.3132	0.4976	0.2669	**	**	NS
CL	0.9430	0.9285	1.0998	0.4664	0.7178	0.3594	**	**	*
CW	1.3046	1.9152	1.3769	0.6636	0.8857	0.5592	NS	NS	NS
AGE	0.9663	1.3164	0.7987	0.0424	0.0595	0.0417	NS	NS	NS
LL64	2.3606	2.4988	2.2605	0.1912	0.8234	0.2346	**	**	NS
LL65	2.1967	2.3052	2.0630	0.2687	0.8654	0.3277	**	**	NS
LL66	2.6467	3.1427	2.4226	0.0141	0.4442	0.1405	**	**	NS
LL67	2.3889	2.6854	2.2140	0.1609	0.6555	0.2442	**	**	NS
LL68	2.3126	2.5620	2.2928	0.2074	0.7359	0.2014	**	**	NS
LLx5	2.3052	2.3426	2.1575	0.0435	0.1774	0.0576	**	**	NS
RW-4	1.8293	2.9051	2.1058	8.5391	12.4822	6.4358	NS	*	NS
RW-3	1.8931	2.9264	2.1374	8.4230	12.4856	6.0533	NS	*	NS
RW-2	2.0734	2.6322	2.2089	8.0811	14.4073	5.9447	**	**	NS
RW-1	2.1543	2.6214	2.0924	7.1485	14.5368	8.3626	**	*	NS
RWx2	2.0864	2.5869	2.1101	3.9986	7.4771	3.8409	**	**	NS
RWx3	1.9842	2.6448	2.0953	2.8798	4.9684	2.4651	**	**	NS
RWx4	1.9095	2.6528	2.0804	2.2595	3.7665	1.8413	**	**	NS
RWx8	1.8829	2.5271	2.0318	1.2295	2.0305	0.9493	**	**	NS
CC	1.0512	1.3569	1.2589	0.4302	0.6564	0.3670	**	**	NS
UCC	0.5588	-0.2348	0.7569.	0.4654	0.8955	0.4150	NS	NS	NS
BCC	-0.0697	-0.8703	0.2350	0.6425	1.1016	0.5640	NS	NS	NS
FCOL	1.6071	2.1967	1.8937	0.5052	0.7748	0.3544	NS	NS	NS
CLPC	1.7987	2.2960	2.0506	0.0185	0.0310	0.0117	NS	NS	NS
CBA	1.9475	2.8680	2.0017	0.1927	0.2349	0.1441	NS	NS	NS
CVOL	2.0560	2.9777	2.1026	0.1123	0.1325	0.0735	NS	**	**
CSA	1.6533	2.3214	1.7324	0.0946	0.0976	0.0533	*	**	*
DH	1.5428	2.1324	1.5844	1.4008	1.9535	1.1404	**	**	*
D2	1.8028	2.5362	1.8279	87.9315	121.8934	72.4543	**	**	NS
D2H	2.0155	2.8862	2.0078	6.8361	8.8164	5.4169	*	**	*
CSSS	3.0194	4.7403	3.1405	-0.0182	-0.0450	-0.0239	*	NS	NS
HCC	1.6397	2.2972	1.7277	0.0306	0.0437	0.0251	**	**	*

APPENDIX 5. NUMBERS OF BRANCHES AND OF BEARING BRANCHES BY WHORL AND INTERNODE IN THE FEMALE ZONE OF EACH OF THIRTEEN TREES IN EACH OF THREE SEED YEARS [1]

		1964						1966						1968					
		All Branches			Bearing Branches			All Branches			Bearing Branches			All Branches			Bearing Branches		
Tree	Position of Whorl or Internode	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total
1	I	5+1[x]	20	25+1	5	20	25	4+1	9	13+1	4	9	13	3+1	10	13+1	3	9	12
	II	4	23	27	4	19	25	4	18	22	4	18	22	3	11	14	3	11	14
	III	6	6	12	6	2	8	5	10	15	5	6	11	4	4	8	4	3	7
	IV	4		4	4		4	4		4	4		4	4		4	4		4
	V							6		6	5		5	5		5	4		4
	Total	19+1	49	68+1	19	41	60	23+1	37	60+1	22	33	55	19+1	25	44+1	18	23	31
2	I	3+1	14	17+1	3	14	17	3+1	10	13+1	3	10	13	4+1	15	19+1	4	15	19
	II	4	18	22	4	17	21	4	12	16	4	12	16	2	8	10	2	8	10
	III	4	4	8	4	2	6	3	13	16	3	12	15	3	7	10	3	7	10
	IV	5		5	4		4	4	8	12	4	6	10	4	1	5	4	1	5
	V							4		4	3		3	3		3	2		2
	Total	16+1	36	52+1	15	33	48	18+1	43	61+1	17	40	57	16+1	31	47+1	15	31	46
3	I	3+1	15	18+1	2	10	12	2+1	6	8+1	2+1	6	8+1	3+1	9	12+1		3	3
	II	3	10	13	3	2	5	3	10	13	3	10	13	3	4	7	3	2	5
	III	4	11	15	2	2	4	3	15	18	3	10	13	2	6	8	2	3	5
	IV	5	5	10	2	1	3	3	1	4	3	1	4	3	7	10	3	4	7
	V							4		4	2		2	3		3	2		2
	Total	15+1	41	56+1	9	15	24	15+1	32	47+1	13+1	27	40+1	14+1	26	40+1	10	12	22
4	I	3+1	15	18+1	3+1	15	18+1	3+1	3	6+1	3+1	3	6+1	3+1	8	11+1	3+1	8	11+1
	II	4	19	23	3	10	13	3	3	6	3	3	6	3	5	8	3	5	8
	III	3	18	21	3	2	5	3	15	18	3	15	18	3	3	6	3	3	6
	IV	3	11	14	2		2	3	14	17	3	2	5	3		3	2		2
	V	3	6	9	3	2	5	3		3	2		2						
	VI	3		3	3		3	3		3	1		1						
	Total	19+1	69	88+1	17+1	29	46+1	18+1	35	53+1	15+1	23	38+1	12+1	16	28+1	11+1	16	27+1

Continued . . .

Appendix 5. Continued

		1964						1966						1968					
		All Branches			Bearing Branches			All Branches			Bearing Branches			All Branches			Bearing Branches		
Tree	Position of Whorl or Internode	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total
5	I	4+1	23	27+1	3	23	26	-	-	-	-	-	-	-	-	-	-	-	-
	II	4	24	28	4	23	27	4	16	20	4	13	17	-	-	-	-	-	-
	III	5	25	30	5	9	14	2	22	26	4	18	22	-	-	-	-	-	-
	IV	4	38	42	4	3	7	4	18	22	4	4	8	4	1	5	4	1	5
	V	3	5	8	1	1	2	5	4	9	5	2	7						
	VI							4		4	1		1						
	Total	20+1	115	135+1	17	59	76	21	60	81	18	37	55	4	1	5	4	1	5
6	I	2+1	6	8+1				3+1	10	13+1	3+1	9	12+1		9	9		4	4
	II	3	20	23	3	9	12	3	9	12	3	9	12	2	4	6	2	2	4
	III	4		4	3		3	2	6	8	2	2	4	2	1	3		1	1
	IV							2	7	9	2	6	8						
	V							4		4	1		1						
	Total	9+1	26	35+1	6	9	15	14+1	32	46+1	11+1	26	37+1	4	14	18	2	7	9
7	I	4+1	11	15+1	4+1	11	15+1	3+1	4	7+1	3+1	4	7+1		3	3		3	3
	II	4	18	22	4	16	20	4	6	10	4	6	10	2	3	5	2	3	5
	III	4	15	19	4	2	6	4	2	6	4	2	6	1	1	2	1	1	2
	IV							4		4	3		3	4		4	1		1
	Total	12+1	44	56+1	12+1	29	41+1	15+1	12	27+1	14+1	12	26+1	7	7	14	4	7	11
8	I	3+1	9	12+1	3	4	7	2+1	7	9+1	2+1	7	9+1	2+1	5	7+1	2	4	6
	II	3	5	8	2	2	4	3	9	12	3	9	12	2	3	5	2	3	5
	III							2	2	4	2	2	4	2		2	1		1
	IV							3		3	1		1						
	Total	6+1	14	20+1	5	6	11	10+1	18	28+1	8+1	18	26+1	6+1	8	14+1	5	7	12
9	I	4+1	9	13+1	4	7	11	-	-	-	-	-	-	-	-	-	-	-	-
	II	4	9	13	4	4	8	4	8	12	4	8	12	-	-	-	-	-	-
	III	4	4	8	4	1	5	4	5	9	4	4	8	-	-	-	-	-	-
	IV	4		4	3		3	4		4	3		3	4	3	7	4	2	6
	V							xx											
	VI							xx											
	VII							1		1	1		1						
	Total	16+1	22	38+1	15	12	27	13	13	26	12	12	24	4	3	7	4	2	6

Continued . . .

Appendix 5. Continued

		1964						1966						1968					
		All Branches			Bearing Branches			All Branches			Bearing Branches			All Branches			Bearing Branches		
Tree	Position of Whorl or Internode	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total	Whorl	Inter-node	Total
10	I	5+1	9	14+1	5	9	14	0+1	0	0+1	0	0	0	3+1	2	5+1		1	1
	II	2	10	12	2	10	12	3	10	13	3	8	11	1	4	5	1	2	3
	III	4	12	16	4	4	8	5	9	14	5	2	7						
	IV	4	4	8	2	1	3	2	5	7	2	2	4	3	5	8	1	1	2
	V	4		4	3		3												
	Total	19+1	35	54+1	16	24	40	10+1	24	34+1	10	12	22	7+1	11	18+1	2	4	6
11	I	4+1	18	22+1				3+1	18	21+1	3	16	19						
	II	4	12	16	2	4	6	4	17	21	4	17	21						
	III	3		3	1		1	4		4	4		4						
	IV							4		4	4		4						
	Total	11+1	30	41+1	3	4	7	15+1	35	50+1	15	33	48						
12	I	4+1	4	8+1		3	3	3+1	8	11+1	3+1	6	9+1	4+1	5	9+1	3		3
	II							4	11	15	4	11	15	4	4	8	4	2	6
	III							4	8	12	4	6	10	3	3	6	3	1	4
	IV							3		3	3		3						
	V							4		4	4		4						
	VI							4		4	2		2						
	Total	4+1	4	8+1		3	3	22+1	27	49+1	20+1	23	43+1	11+1	12	23+1	10	3	13
13	I	3+1	6	9+1		4	4	3+1	7	10+1	3	7	10	4+1	11	15+1	1	3	4
	II							4	13	17	4	13	17	3	5	8	2	4	6
	III							3		3	3		3						
	IV							3		3	2		2						
	V							4		4	2		2						
	Total	3+1	6	9+1		4	4	17+1	20	37+1	14	20	34	7+1	16	23+1	3	7	10

1 The numbers of branches in whorls and in internodes are the numbers upwards from the branch on which the lowest female cone occurs in each category.

x The +1 represents the leading shoot of the tree.

xx Values omitted since female occurrence below is a distinct outlier.

\- Top of tree broken, therefore no values possible.

APPENDIX 6. CONE PRODUCTION BY ASPECT IN WHORLS AND INTERNODES FOR THIRTEEN TREES IN THREE SEED YEARS

Tree	Position of Whorl or Internode	Whorl North	Whorl East	Whorl South	Whorl West	Internode North	Internode East	Internode South	Internode West	Whorl & Internode North	Whorl & Internode East	Whorl & Internode South	Whorl & Internode West
A. 1964													
1	I	4	2	1	3	5	10	9	16	9	12	10	19
	II	21	21	18	17	26	14	20	19	47	35	38	36
	III	45	39	81	59			4		45	39	85	59
	IV	11	18	2	1					11	18	2	1
	Total	81	80	102	80	31	24	33	35	112	104	135	115
2	I	4	3	3	3	6	9	6	3	10	12	9	6
	II	13	11	11	13	17	14	17	15	30	25	28	28
	III	6	8	10	4	1			2	7	8	10	6
	IV	9	4	2	2					9	4	2	2
	Total	32	26	26	22	24	23	23	20	56	49	49	42
3	I		1	1		6	4	3	5	6	5	4	5
	II		9	9	8	5			2	5	9	9	10
	III			17	15				4			17	19
	IV	7	15					3		7	15	3	
	Total	7	25	27	23	11	4	6	11	18	29	33	34
4	I	2	5	6	4	9	5	8	7	11	10	14	11
	II		13	11	11	11	21	11	5	11	34	22	16
	III	3		24	19	7		9		10		33	19
	IV		27	25							27	25	
	V	9	21	20				2		9	21	22	
	VI	2	2		3					2	2		3
	Total	16	68	86	37	27	26	30	12	43	92	116	49
5	I		1	1	1	8	12	16	8	8	13	17	9
	II	14	19	21	19	29	35	33	15	43	54	54	34
	III	47	46	53	36	14	9	21	5	61	55	74	41
	IV	5		23	2	1	1	1		6	1	24	2
	V	2						1		2		1	
	Total	68	66	98	58	52	57	72	28	120	123	170	86
6	I												
	II	3		11	1	2	7	10	1	5	7	21	2
	III	1	4	5						1	4	5	
	Total	4	4	16	1	2	7	10	1	6	11	26	2
7	I	5	1	7	4	6	2	6	9	11	3	13	13
	II	14	16	16	11	19	22	27	14	33	38	43	25
	III	15	16	11	15			2		15	16	13	15
	Total	34	33	34	30	25	24	35	23	59	57	69	53
8	I		1	1	1	2		3	2	2	1	4	3
	II		2		1			2			2	2	1
	Total		3	1	2	2		5	2	2	3	6	4
9	I	1	1	1	1	4	2	6	1	5	3	7	2
	II	5	10	6	5		1	4	1	5	11	10	6
	III	8	13	6	3			4		8	13	10	3
	IV	1	3	1						1	3	1	
	Total	15	27	14	9	4	3	14	2	19	30	28	11

Continued . . .

Appendix 6. A. 1964 Continued

Tree	Position of Whorl or Internode	Whorl North	Whorl East	Whorl South	Whorl West	Internode North	Internode East	Internode South	Internode West	Whorl & Internode North	Whorl & Internode East	Whorl & Internode South	Whorl & Internode West
10	I	2	2	2	2	7	2	6	1	9	4	8	3
	II		10		13	10	9	14	12	10	19	14	25
	III		6	33	6		6	2	8		12	35	14
	IV	1			3			1		1		1	3
	V		1	1	1						1	1	1
	Total	3	19	36	25	17	17	23	21	20	36	59	46
11	I												
	II	1			1			4	1	1		4	2
	III		1	1							1	1	
	Total	1	1	1	1			4	1	1	1	5	2
12	I					2		2		2		2	
	Total					2		2		2		2	
13	I					3	1	2	1	3	1	2	1
	Total					3	1	2	1	3	1	2	1
Mean Total		20.1	27.1	33.9	22.2	15.4	14.4	19.9	12.1	35.5	41.4	53.8	34.2
B. 1966													
1	I	2	2	3	2	4	4	2	4	6	6	5	6
	II	17	17	15	20	32	22	34	21	49	39	49	41
	III	64	54	69	50	4	17	23	1	68	71	92	51
	IV	23	34	19	15					23	34	19	15
	V	3	9	1	5					3	9	1	5
	Total	109	116	107	92	40	43	59	26	149	159	166	118
2	I		5	5	4	5	4	4	6	5	9	9	10
	II	17	19	18	16	29	17	20	19	46	36	38	35
	III	19	23	27	10	15	13	27	7	34	36	54	17
	IV	16	13	11	20	3		8	1	19	13	19	21
	V	5		6	1					5		6	1
	Total	57	60	67	51	52	34	59	33	109	94	126	84
3	I	3	1		4	3	3	3		6	4	3	4
	II	6	2	9	10	9	10	11	5	15	12	20	15
	III	13	15	25	23	7	10	17	21	20	25	42	44
	IV	19	20	20	21	6				25	20	20	21
	V			7	6							7	6
	Total	41	38	61	64	25	23	31	26	66	61	92	90
4	I	7	5	2	4			4	1	7	5	6	5
	II	5		5	6		4	6	4	5	4	11	10
	III	4	11	7	15	38	24	34	37	42	35	41	52
	IV		10	38	27		1	3			11	41	27
	V		1		2						1		2
	VI		1								1		
	Total	16	28	52	54	38	29	47	42	54	57	99	96
5	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	6	9	7	7	17	18	6	8	23	27	13	15
	III	37	22	38	36	29	29	29	30	66	51	67	66
	IV	54	44	30	43	1	8	20		55	52	50	43
	V	20	19	26	35	1	1			21	20	26	35
	VI			1								1	
	Total	117	94	102	121	48	56	55	38	165	150	157	159

Continued . . .

Appendix 6. B. 1966 Continued

Tree	Position of Whorl or Internode	Whorl				Internode				Whorl & Internode			
		North	East	South	West	North	East	South	West	North	East	South	West
6	I	5		5	5	2	2	10	9	7	2	15	14
	II	4	13	21		22	8	6	9	26	21	27	9
	III	4	8	11		1	2			5	10	11	
	IV	29	2		27	6	5	4	1	35	7	4	28
	V	1								1			
	Total	43	23	37	32	31	17	20	19	74	40	57	51
7	I	4	4	5			3		4	4	7	5	4
	II	9	10	7	11		11	5	9	9	21	12	20
	III	13	8	8	11		2	2		13	10	10	11
	IV	9		2	1					9		2	1
	Total	35	22	22	23		16	7	13	35	38	29	36
8	I	1	1	2	1	1	3	2	4	2	4	4	5
	II	7	1	6	7	10	4	13	5	17	5	19	12
	III			6	8	2		2		2		8	8
	IV			7								7	
	Total	8	2	21	16	13	7	17	9	21	9	38	25
9	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	17		18	11	17	5	13	11	34	5	31	22
	III	20	18	22	22	11		11	2	31	18	33	24
	IV	2	3		3					2	3		3
	V												
	VI												
	VII		1								1		
	Total	39	22	40	36	28	5	24	13	67	27	64	49
10	I												
	II	10	11	10	8	10	3	23	11	20	14	33	19
	III	3	3	20	9			1	1	3	3	21	10
	IV		6		2		2	1			8	1	2
	Total	13	20	30	19	10	5	25	12	23	25	55	31
11	I	3	1		3	9	4	8	7	12	5	8	10
	II	26	7	39	21	17	9	22	26	43	16	61	47
	III	32	28	10	43					32	28	10	43
	IV	5	3	3	2					5	3	3	2
	Total	66	39	52	69	26	13	30	33	92	52	82	102
12	I	1	4	2	4	2	2	3	3	3	6	5	7
	II	10	11	10	8	7	11	15	11	17	22	25	19
	III	24	30	21	20	1	1	7	12	25	31	28	32
	IV	7	13	30	12					7	13	30	12
	V	9	1	5	5					9	1	5	5
	VI		1	2							1	2	
	Total	51	60	70	49	10	14	25	26	61	74	95	75
13	I	4	2		3	2	1	6	3	6	3	6	6
	II	11	11	14	18	12	11	20	10	23	22	34	28
	III		13	18	14						13	18	14
	IV		6	7							6	7	
	V	1			1					1			1
	Total	16	32	39	36	14	12	26	13	30	44	65	49
	Mean Total	47.0	42.8	53.8	50.9	25.8	21.1	32.7	23.3	72.8	63.9	86.5	74.2

Continued . . .

Appendix 6. Continued

Tree	Position of Whorl or Internode	Whorl North	Whorl East	Whorl South	Whorl West	Internode North	Internode East	Internode South	Internode West	Whorl & Internode North	Whorl & Internode East	Whorl & Internode South	Whorl & Internode West
C. 1968													
1	I		3	2	1	2	3	4	4	2	6	6	5
	II	13	10	4	13	11	18	12	14	24	28	16	27
	III	27	33	37	36		8	11	3	27	41	48	39
	IV	26	31	35	25					26	31	35	25
	V	26	6	5	2					26	6	5	2
	Total	92	83	83	77	13	29	27	21	105	112	110	98
2	I	3	2	3	2	8	2	9	8	11	4	12	10
	II	16		12		16	6	15	12	32	6	27	12
	III		28	17	28	18		15	16	18	28	32	44
	IV	17	1	9	14		1			17	2	9	14
	V		1	2							1	2	
	Total	36	32	43	44	42	9	39	36	78	41	82	80
3	I						1	1	1		1	1	1
	II	5	3	4	1			4		5	3	8	1
	III	8	1	1	8	1	2	2	1	9	3	3	9
	IV	5	6	13	5		2	3	2	5	8	16	7
	V		2	3							2	3	
	Total	18	12	21	14	1	5	10	4	19	17	31	18
4	I	3	3	1	2	6	2	5	2	9	5	6	4
	II	2	9	11	7	4	4	4	6	6	13	15	13
	III	2	2		1			2	2	2	2	2	3
	IV	7	2		1					7	2		1
	Total	14	16	12	11	10	6	11	10	24	22	23	21
5	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
	IV	8	15	17	4	1				9	15	17	4
	Total	8	15	17	4	1				9	15	17	4
6	I	-	-	-	-	2	2		2	2	2		2
	II			1	1	2			2	2		1	3
	III								1				1
	Total			1	1	4	2		5	4	2	1	6
7	I	-	-	-	-	3		2	1	3		2	1
	II	12		19	2	1	4	6		13	4	25	2
	III	7			3		1			7	1		3
	IV	2								2			
	Total	21		19	5	4	5	8	1	25	5	27	6
8	I		1		2	2		1	1	2	1	1	3
	II		6		5	5		1	2	5	6	1	7
	III	2								2			
	Total	2	7		7	7		2	3	9	7	2	10
9	I	-	-	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-	-	-
	IV	11	3	8	9	2		1		13	3	9	9
	Total	11	3	8	9	2		1		13	3	9	9

Continued . . .

Appendix 6. C. 1968 Continued

Tree	Position of Whorl or Internode	Whorl				Internode				Whorl & Internode			
		North	East	South	West	North	East	South	West	North	East	South	West
10	I						1				1		
	II			1	3			2	1			3	4
	III												
	IV	1						1		1		1	
	Total	1		1	3		1	3	1	1	1	4	4
11	No Cones Borne												
12	I	1	1		1					1	1		1
	II	4	3	1	3	1		1		5	3	2	3
	III		2	2	1				1		2	2	2
	Total	5	6	3	5	1		1	1	6	6	4	6
13	I				1	1			2	1			3
	II	1	1	1		5	1	1		6	2	2	
	Total	1	1	1	1	6	1	1	2	7	2	2	3
	Mean Total	17.4	14.6	17.4	15.1	7.6	4.8	8.6	7.0	25.0	19.4	26.0	22.1

\- No branches produced, a result of breakage of the leading shoot.

APPENDIX 7. CONE PRODUCTION BY SHOOT ORDERS IN WHORLS AND INTERNODES FOR THIRTEEN TREES IN THE THREE SEED YEARS

Position on Tree (whorl or internode)	Shoot Order																	
	1964						1966						1968					
	9	8	7	6	5	4	9	8	7	6	5	4	9	8	7	6	5	4
Tree No. 1																		
W-I		10						9						6				
I-I		40						14						13				
W-II		10	67					18	51					9	31			
I-II		39	40					40	69					26	29			
W-III		18	84	122				18	65	154				12	42	79		
I-III		2	2					8	20	17				6	13	3		
W-IV		3	15	14				4	20	45	22			8	37	40	32	
I-IV																		
W-V									4	12	2			5	14	13	7	
I-V																		
W-Total		41	166	136				49	140	211	24			40	124	132	39	
I-Total		81	42					62	89	17				45	42	3		
Tree No. 2																		
W-I		13						14						10				
I-I		24						19						27				
W-II		9	39					17	53					6	22			
I-II		25	38					31	54					16	33			
W-III		6	16	6				11	27	41				6	25	42		
I-III		1	2					18	21	23				8	25	16		
W-IV		2	8	7				4	5	31	20			7	13	6	15	
I-IV								6	3	3					1			
W-V								4	4	3	1				2	1		
I-V																		
W-Total		30	63	13				50	89	75	21			29	62	49	15	
I-Total		50	40					74	78	26				51	59	16		
Tree No. 3																		
W-I		2					3	5										
I-I		18						9						3				
W-II		1	25					9	18					3	10			
I-II		4	3					18	17					2	2			
W-III		5	16	11				7	18	51				3	8	7		
I-III		2	2					11	14	30				2		4		
W-IV		3	8	11				6	4	28	42			5	4	8	12	
I-IV		2	1					3	1		2			4	1	2		
W-V								2		3	7	1		1	1	2	1	
I-V																		
W-Total		11	49	22			3^x	29	40	82	49	1		12	23	17	13	
I-Total		26	6					41	32	30	2			11	3	6		
Tree No. 4																		
W-I	9	8					8	10					1	8				
I-I		29						5						15				
W-II		9	26					6	10					7	22			
I-II		18	30					6	8					7	11			
W-III		5	16	25				7	12	18				4	1			
I-III		4	10	2				30	39	64				2	2	4		
W-IV		3	17	32				5	8	23	38			2	4			
I-IV								2		1	2							
W-V		4	17	29						1	2							
I-V		2																
W-VI		2	2	3				1										
I-VI																		
W-Total	9	31	78	89			8	29	30	42	40		1	21	27	4		
I-Total		53	40	2				43	47	65	2			24	13			

Continued . . .

Appendix 7. Continued

Position on Tree (whorl or internode)	Shoot order 1964						1966						1968					
	9	8	7	6	5	4	9	8	7	6	5	4	9	8	7	6	5	4
Tree No. 5																		
W-I		3					-	-					-	-				
I-I		44						-						-				
W-II		6	67					1	28					-	-			
I-II		47	65					19	30					-	-			
W-III		10	69	103				8	31	94				-	-			
I-III		8	29	12				26	31	60				-	-			
W-IV		1	14	9	6			5	6	61	99				13	22	9	
I-IV		3						3	5	12	9			1				
W-V			2					3	4	54	39							
I-V			1						1	1								
W-VI										1								
I-VI																		
W-Total		20	152	112	6			17	69	210	138				13	22	9	
I-Total		102	95	12				48	67	73	9			1				
Tree No. 6																		
W-I							1	14										
I-I								23						6				
W-II		1	14					13	25						2			
I-II		8	12					18	27					2	2			
W-III		1	6	3				4	7	12								
I-III									3							1		
W-IV								3	7	43	5							
I-IV								1	1	11	3							
W-V										1								
I-V																		
W-Total		2	20	3			1	34	39	56	5				2			
I-Total		8	12					42	31	11	3			8	2	1		
Tree No. 7																		
W-I	2	15					1	9						-				
I-I		23						7						6				
W-II		16	41					15	22					7	26			
I-II		37	45					12	13					7	4			
W-III		11	21	25				15	9	16				4	3	3		
I-III		1		1				2	1	1						1		
W-IV								7	2	3				2				
I-IV																		
W-Total	2	42	62	25			4	46	33	19				13	29	3		
I-Total		61	45	1				21	14	1				13	4	1		
Tree No. 8																		
W-I		3					2	3						3				
I-I		7						10						4				
W-II			3					6	15					5	6			
I-II		1	1					16	16					4	4			
W-III								2	4	8				1	1			
I-III								2	2									
W-IV								1	2	4								
I-IV																		
W-Total		3	3				2	12	21	12				9	7			
I-Total		8	1					28	18					8	4			
Tree No. 9																		
W-I		4					-	-					-	-				
I-I		13						-						-				
W-II		3	23					13	33					-	-			
I-II		5	1					16	30					-	-			
W-III		7	19	4				14	24	44				-	-			
I-III		1	3					7	8	9				-	-			
W-IV			4	1				4	1	3				4	7	14	6	
I-IV														2	1			
W-V & VI																		
I-V & VI																		
W-VII									1									
I-VII																		
W-Total		14	46	5				31	59	47				4	7	14	6	
I-Total		19	4					23	38	9				2	1			

Appendix 7. Continued

Position on Tree (whorl or internode)	Shoot order 1964 9	8	7	6	5	4	1966 9	8	7	6	5	4	1968 9	8	7	6	5	4
<u>Tree No. 10</u>																		
W-I		8																
I-I		16												1				
W-II		1	22					2	37					1	3			
I-II		19	26					12	35					3				
W-III		7	31	7				6	13	16								
I-III		9	6	1				2										
W-IV		1	2	1				1	2	5						1		
I-IV			1					1		2						1		
W-V			3															
I-V																		
W-Total		17	58	8				9	52	21				1	3	1		
I-Total		44	33	1				15	35	2				4		1		
<u>Tree No. 11</u>																		
W-I								7										
I-I								28										
W-II			2					12	81									
I-II		3	2					19	55									
W-III			1	1				8	44	61								
I-III																		
W-IV								4	6	3								
I-IV																		
W-Total			3					31	131	64								
I-Total		3	2	1				47	55									
<u>Tree No. 12</u>																		
W-I							5	6						3				
I-I		4						10										
W-II								12	27					5	6			
I-II								20	24					2				
W-III								11	24	60				1	2	2		
I-III								9	5	7				1				
W-IV								9	11	40	2							
I-IV																		
W-V								5	8	6	1							
I-V																		
W-VI								2			1							
I-VI																		
W-Total							5	45	70	106	4			9	8	2		
I-Total		4						39	29	7				3				
<u>Tree No. 13</u>																		
W-I								9						1				
I-I		7						12						3				
W-II								14	40						3			
I-II								17	36					1	6			
W-III								8	21	16								
I-III																		
W-IV								2	10	1								
I-IV																		
W-V									1	1								
I-V																		
W-Total								33	72	18				1	3			
I-Total		7						29	36					4	6			

x Numbers of cones on the leading shoot (shoot order 9) are shown under total for whorl branches.
\- No branches produced, a result of breakage of the leading shoot.

APPENDIX 8. COMPARISONS OF REGRESSIONS OF VARIOUS CONE-SIZE MEASURES BY TREES BETWEEN YEARS

Tree	Relationship		DF	Sums of Products: Sum x^2	Sum xy	Sum y^2	Regres. Coef.	Deviations from Regression: DF	Sum Squares	Mean Square	F
3	Cone length on No. scales	1964	28	6661.0	250.86	11.281	0.0377	27	1.8338	0.0679	
		1966	39	15884.8	555.85	22.104	.0350	38	2.6532	.0698	
								65	4.4870	.0698	
		Pooled	67	22545.8	806.71	33.385		66	4.5197	.0685	
				Differences between slopes				1	0.0327	.0327	0.47 NS
		Total	68	26501.3	739.28	34.575		67	13.9528	.2082	
				Differences between adjusted means				1	9.4331	9.4331	137.75 **
	Cone diameter on No. scales	1964	28	6661.0	36.33	0.289	0.0055	27	0.0904	0.0034	
		1966	39	15884.8	69.31	.428	.0044	38	.1258	.0033	
								65	.2162	.0033	
		Pooled	67	22545.8	105.64	.717		66	.2217	.0034	
				Differences between slopes				1	.0055	.0055	1.65 NS
		Total	68	26501.3	46.20	1.609		67	1.5283	.0228	
				Differences between adjusted means				1	1.3066	1.3066	390.02 **
	Cone weight plus seed on No. scales	1964	28	6661.0	455.55	34.881	0.0684	27	3.7257	0.1380	
		1966	39	15884.8	955.82	61.986	.0602	38	4.4718	.1177	
								65	8.1975	.1261	
		Pooled	67	22545.8	1411.38	96.867		66	8.5143	.1290	
				Differences between slopes				1	0.3168	.3168	2.51 NS
		Total	68	26501.3	1293.67	100.445		67	37.2922	.5566	
				Differences between adjusted means				1	28.7779	28.7779	223.08 **
	Cone weight minus seed on No. scales	1964	28	6661.0	339.62	19.252	0.0510	27	1.9356	0.0717	
		1966	39	15884.8	680.72	32.685	.0428	38	3.5139	.0925	
								65	5.4495	.0838	
		Pooled	67	22545.8	1020.34	51.937		66	5.7595	.0873	
				Differences between slopes				1	0.3100	.3100	3.68 NS
		Total	68	26501.3	854.42	58.922		67	31.3748	.4683	
				Differences between adjusted means				1	25.6153	25.6153	293.55 **
6	Cone length on No. scales	1964	11	841.0	31.35	1.689	0.0373	10	0.5209	0.0521	
		1966	22	7274.9	210.64	8.438	0.0290	21	2.3390	.1114	
								31	2.8599	.0922	
		Pooled	33	8115.9	241.99	10.127		32	2.9120	.0910	
				Differences between slopes				1	0.0521	.0521	0.56 NS
		Total	34	8141.7	231.30	14.566		33	7.9952	.2423	
				Differences between adjusted means				1	5.0832	5.0832	55.86 **
	Cone diameter on No. scales	1964	11	841.0	2.00	0.020	0.0024	10	0.0152	0.0015	Variances heterogeneous[1]
		1966	22	7274.9	44.23	.410	.0061	21	.1409	.0067	
	Cone weight plus seed on No. scales	1964	11	841.0	43.50	2.740	0.0517	10	0.4905	0.0490	Variances heterogeneous
		1966	22	7274.9	271.48	14.389	.0373	21	4.2584	.2028	

Continued . . .

Appendix 8 Continued

Tree	Relationship		DF	Sum x^2	Sum xy	Sum y^2	Regres. Coef.	DF	Sum Squares	Mean Square	F
				Sums of Products				Deviations from Regression			
6 (cont.)	Cone weight minus seed on No. scales	1964	11	841.0	31.80	1.520	0.0378	10	0.3179	0.0318	
		1966	22	7274.9	168.12	5.818	.0231	21	1.9328	.0920	
								31	2.2507	.0726	
		Pooled	33	8115.9	199.92	7.338		32	2.4135	.0754	
				Differences between slopes				1	0.1628	.1628	2.24 NS
		Total	34	8141.7	186.60	14.222		33	9.9452	.3014	
				Differences between adjusted means				1	7.5317	7.5317	99.86 **
8	Cone length on No. scales	1964	13	852.4	36.80	2.312	0.0432	12	0.7228	0.0602	
		1966	25	4868.6	201.86	9.679	.0415	24	1.3094	.0546	
								36	2.0322	.0564	
		Pooled	38	5721.0	238.66	11.991		37	2.0342	.0550	
				Differences between slopes				1	0.0020	.0020	0.04 NS
		Total	39	7027.6	428.96	39.703		38	13.5196	.3558	
				Differences between adjusted means				1	11.4854	11.4854	208.94 **
	Cone diameter on No. scales	1964	13	852.4	5.90	0.060	0.0069	12	0.0192	0.0016	Variances heterogeneous
		1966	25	4868.6	48.33	.727	.0099	24	.2470	.0103	
	Cone weight plus seed on No. scales	1964	13	852.4	70.05	7.574	0.0822	12	1.8168	0.1514	
		1966	25	4868.6	292.34	19.658	.0600	24	2.1043	.0877	
								36	3.9211	.1089	
		Pooled	38	5721.0	362.39	27.232		37	4.2766	.1156	
				Differences between slopes				1	0.3555	.3555	3.26 NS
		Total	39	7027.6	628.74	81.524		38	25.2734	.6651	
				Differences between adjusted means				1	20.9968	20.9968	181.66 **
	Cone weight minus seed on No. scales	1964	13	852.4	44.06	3.370	0.0517	12	1.0921	0.0910	
		1966	25	4868.6	192.42	8.534	.0395	24	0.9286	.0387	
								36	2.0207	.0561	
		Pooled	38	5721.0	236.48	11.904		37	2.1281	.0575	
				Differences between slopes				1	0.1074	.1074	1.91 NS
		Total	39	7027.6	430.88	40.824		38	14.4058	.3791	
				Differences between adjusted means				1	12.2777	12.2777	213.49 **
	Cone length on No. scales	1966	25	4868.6	201.86	9.679	0.0415	24	1.3094	0.0546	
		1968	17	1120.9	36.69	3.060	.0327	16	1.8586	.1162	
								40	3.1680	.0792	
		Pooled	42	5989.5	238.55	12.739		41	3.2376	.0790	
				Differences between slopes				1	0.0696	.0696	0.88 NS
		Total	43	5994.9	240.68	13.577		42	3.9140	.0932	
				Differences between adjusted means				1	0.6764	.6764	8.57 **
	Cone diameter on No. scales	1966	25	4868.6	48.33	0.727	0.0099	24	0.2470	0.0103	
		1968	17	1120.9	11.73	.316	.0105	16	.1934	.0121	
								40	.4404	.0110	
		Pooled	42	5989.5	60.06	1.043		41	.4407	.0107	
				Differences between slopes				1	.0003	.0003	0.03 NS
		Total	43	5994.9	60.92	1.187		42	.5678	.0135	
				Differences between adjusted means				1	.1271	.1271	11.84 **

Continued . . .

Appendix 8. Continued

Tree	Relationship		DF	Sums of Products: Sum x^2	Sum xy	Sum y^2	Regres. Coef.	Deviations from Regression: DF	Sum Squares	Mean Square	F
8 (cont.)	Cone weight plus seed on No. scales	1966	25	4868.6	292.34	19.658	0.0600	24	2.1043	0.0877	
		1968	17	1120.9	70.88	6.902	.0632	16	2.4198	.1512	
								40	4.5241	.1131	
		Pooled	42	5989.5	363.22	26.560		41	4.5333	.1106	
				Differences between slopes				1	0.0092	.0092	0.08 NS
		Total	43	5994.9	366.66	28.752		42	6.3269	.1506	
				Differences between adjusted means				1	1.7936	1.7936	16.22 **
	Cone weight minus seed on No. scales	1966	25	4868.6	192.42	8.534	0.0395	24	0.9286	0.0387	Variances heterogeneous
		1968	17	1120.9	46.69	3.689	.0416	16	1.7438	.1090	
	Cone length on No. scales	1964	13	852.4	36.80	2.312	0.0432	12	0.7228	0.0602	
		1968	17	1120.9	36.69	3.060	.0327	16	1.8586	.1162	
								28	2.5814	.0922	
		Pooled	30	1973.3	73.49	5.372		29	2.6347	.0908	
				Differences between slopes				1	0.0533	.0533	0.58 NS
		Total	31	2973.5	203.44	22.256		30	8.3364	.2779	
				Differences between adjusted means				1	5.7017	5.7017	62.76 **
	Cone diameter on No. scales	1964	13	852.4	5.90	0.060	0.0069	12	0.0192	0.0016	Variances heterogeneous
		1968	17	1120.9	11.73	.316	.0105	16	.1934	.0121	
	Cone weight plus seed on No. scales	1964	13	852.4	70.05	7.574	0.0822	12	1.8168	0.1514	
		1968	17	1120.9	70.88	6.902	.0632	16	2.4198	.1512	
								28	4.2366	.1513	
		Pooled	30	1973.3	140.93	14.475		29	4.4106	.1521	
				Differences between slopes				1	0.1740	.1740	1.15 NS
		Total	31	2973.5	317.40	45.612		30	11.7330	.3911	
				Differences between adjusted means				1	7.3224	7.3224	48.15 **
	Cone weight minus seed on No. scales	1964	13	852.4	44.06	3.370	0.0517	12	1.0921	0.0910	
		1968	17	1120.9	46.69	3.688	.0416	16	1.7438	.1090	
								28	2.8359	.1013	
		Pooled	30	1973.3	90.75	7.059		29	2.8848	.0995	
				Differences between slopes				1	0.0488	.0488	0.48 NS
		Total	31	2973.5	193.26	17.567		30	5.0061	.1669	
				Differences between adjusted means				1	2.1213	2.1213	21.33 **
9	Cone length on No. scales	1964	20	3091.0	115.26	4.809	0.0373	19	0.5113	0.0269	
		1966	31	9465.0	236.41	6.954	.0250	30	1.0497	.0350	
								49	1.5610	.0318	
		Pooled	51	12556.0	351.67	11.763		50	1.9136	.0383	
				Differences between slopes				1	0.3526	.3526	11.07 **
	Cone diameter on No. scales	1964	20	3091.0	13.85	0.132	0.0045	19	0.0705	0.0037	
		1966	31	9465.0	60.98	.489	.0064	30	.0963	.0032	
								49	.1668	.0034	
		Pooled	51	12556.0	74.83	.621		50	.1757	.0035	
				Differences between slopes				1	.0089	.0089	2.62 NS
		Total	52	12919.8	60.09	1.215		51	.9358	.0184	
				Differences between adjusted means				1	.7602	.7602	216.57 **

Continued . . .

Tree	Relationship		DF	Sums of Products: Sum x^2	Sum xy	Sum y^2	Regres. Coef.	Deviations from Regression: DF	Sum Squares	Mean Square	F
9 (cont.)	Cone weight plus seed on No. scales	1964	20	3091.0	152.33	8.514	0.0493	19	1.0068	0.0530	
		1966	31	9465.0	420.44	20.925	.0444	30	2.2491	.0750	
								49	3.2559	.0664	
		Pooled	51	12556.0	572.77	29.439		50	3.3110	.0662	
				Differences between slopes				1	0.0551	.0551	0.83 NS
		Total	52	12919.8	557.06	30.114		51	6.0960	.1195	
				Differences between adjusted means				1	2.7850	2.7850	42.06 **
	Cone weight minus seed on No. scales	1964	20	3091.0	111.40	4.425	0.0360	19	0.4102	0.0216	
		1966	31	9465.0	269.57	8.554	.0285	30	.8763	.0292	
								49	1.2865	.0262	
		Pooled	51	12556.0	380.97	12.979		50	1.4197	.0284	
				Differences between slopes				1	0.1332	.1332	5.07 *
	Cone length on No. scales	1966	31	9465.0	236.41	6.954	0.0250	30	1.0497	0.0350	
		1968	13	1036.4	29.34	1.464	.0283	12	0.6334	.0528	
								42	1.6831	.0401	
		Pooled	44	10501.4	265.75	8.418		43	1.6933	.0394	
				Differences between slopes				1	0.0102	.0102	0.25 NS
		Total	45	11385.0	289.74	9.070		44	1.6962	.0386	
				Differences between adjusted means				1	0.0029	.0029	0.07 NS
	Cone diameter on No. scales	1966	31	9465.0	60.98	0.489	0.0064	30	0.0963	0.0032	
		1968	13	1036.4	6.33	.094	.0061	12	.0557	.0046	
								42	.1520	.0036	
		Pooled	44	10501.4	67.31	.583		43	.1520	.0035	
				Differences between slopes				1	.0001	.0001	0.03 NS
		Total	45	11385.0	66.21	.585		44	.1998	.0045	
				Differences between adjusted means				1	.0478	.0478	13.53 **
	Cone weight plus seed on No. scales	1966	31	9465.0	420.44	20.925	0.0444	30	2.2491	0.0750	Variances heterogeneous
		1968	13	1036.4	63.13	7.698	.0609	12	3.8526	.3210	
	Cone weight minus seed on No. scales	1966	31	9465.0	269.57	8.554	0.0285	30	0.8763	0.0292	Variances heterogeneous
		1968	13	1036.4	46.85	4.682	.0452	12	2.5637	.2136	
	Cone length on No. scales	1964	20	3091.0	115.26	4.809	0.0373	19	0.5113	0.0269	
		1968	13	1036.4	29.34	1.464	.0283	12	.6334	.0528	
								31	1.1447	.0369	
		Pooled	33	4127.4	144.60	6.273		32	1.2074	.0377	
				Differences between slopes				1	0.0627	.0627	1.70 NS
		Total	34	4272.9	165.00	9.130		33	2.7585	.0836	
				Differences between adjusted means				1	1.5511	1.5511	41.11 **

Continued . . .

Tree	Relationship		DF	Sums of Products: Sum x^2	Sum xy	Sum y^2	Regres. Coef.	Deviations from Regression: DF	Sum Squares	Mean Square	F
9 (cont.)	Cone diameter on No. scales	1964	20	3091.0	13.85	0.132	0.0045	19	0.0705	0.0037	
		1968	13	1036.4	6.33	.094	.0061	12	.0557	.0046	
								31	.1262	.0041	
		Pooled	33	4127.4	20.18	.227		32	.1282	.0040	
				Differences between slopes				1	.0020	.0020	0.49 NS
		Total	34	4272.9	27.33	.579		33	.4042	.0122	
				Differences between adjusted means				1	.2761	.2761	69.02 **
	Cone weight plus seed on No. scales	1964	20	3091.0	152.33	8.514	0.0493	19	1.0068	0.0530	Variances heterogeneous
		1968	13	1036.4	63.13	7.698	.0609	12	3.8526	.3210	
	Cone weight minus seed on No. scales	1964	20	3091.0	111.40	4.425	0.0360	19	0.4102	0.0216	Variances heterogeneous
		1968	13	1036.4	46.85	4.682	.0452	12	2.5637	.2136	
10	Cone length on No. scales	1964	8	2056.2	44.59	1.416	0.0217	7	0.4490	0.0641	
		1966	23	6859.8	226.10	8.999	.0400	22	1.5462	.0703	
								29	1.9952	.0688	
		Pooled	31	8916.0	270.69	10.415		30	2.1963	.1065	
				Differences between slopes				1	0.2011	.2011	2.92 NS
		Total	32	8923.0	265.44	14.402		31	6.5060	.2099	
				Differences between adjusted means				1	4.3097	4.3097	40.45 **
	Cone diameter on No. scales	1964	8	2056.2	9.91	0.116	0.0048	7	0.0678	0.0097	
		1966	23	6859.8	42.59	.410	.0062	22	.1454	.0066	
								29	.2132	.0074	
		Pooled	31	8916.0	52.50	.526		30	.2161	.0072	
				Differences between slopes				1	.0029	.0029	0.40 NS
		Total	32	8923.0	51.50	.670		31	.3729	.0120	
				Differences between adjusted means				1	.1568	.1568	21.78 **
	Cone weight plus seed on No. scales	1964	8	2056.2	83.19	4.554	0.0405	7	1.1876	0.1697	
		1966	23	6859.8	302.00	15.838	.0440	22	2.5430	.1156	
								29	3.7306	.1286	
		Pooled	31	8916.0	385.19	20.392		30	3.7507	.1250	
				Differences between slopes				1	0.0201	.0201	0.16 NS
		Total	32	8923.0	381.86	21.988		31	5.6466	.1822	
				Differences between adjusted means				1	1.8960	1.8960	15.16 **
	Cone weight minus seed on No. scales	1964	8	2056.2	53.74	1.980	0.0261	7	0.5758	0.0823	
		1966	23	6859.8	184.21	5.736	.0268	22	.7896	.0359	
								29	1.3654	.0471	
		Pooled	31	8916.0	237.95	7.716		30	1.4662	.0489	
				Differences between slopes				1	0.1008	.1008	2.14 NS
		Total	32	8923.0	234.23	9.697		31	3.5480	.1144	
				Differences between adjusted means				1	2.0818	2.0818	42.60 **

[1] Variances tested for homogeneity using Bartlett's test (Snedecor and Cochran, 1967 p. 296).

APPENDIX 9

TABLES FOR ESTIMATION OF THE TOTAL NUMBER OF SCALES (TSCN) PER CONE ACCORDING TO POSITION ON THE TREE

The tables provide estimates using the best predictive combination of a measure of relative height (RH1, RH2, RH3 or RH4) and shoot order (ORD) for each tree for which adequate data were obtained. These trees are numbers 1 to 10, 1964, numbers 1 to 12, 1966 and numbers 1, 2, 4 and 8, 1968.

N.B. The tables, as constructed, provide values for TSCN (many inordinately low) for some combinations of RH and ORD which are physically impossible

APPENDIX 9

1964 TREE 1 TSCN = Y = -28.459 + 19.434X1 + 0.414X2

X1 = RH2	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	89.80	43.94	90.21	42.80	90.62	42.51	91.04	43.09	91.45	44.51
6.2	93.68	43.54	94.10	42.32	94.51	41.96	94.92	42.48	95.34	43.84
6.4	97.57	43.19	97.98	41.88	98.40	41.44	98.81	41.89	99.22	43.20
6.6	101.46	42.87	101.87	41.48	102.28	40.95	102.70	41.33	103.11	42.59
6.8	105.34	42.58	105.76	41.10	106.17	40.50	106.58	40.81	107.00	42.01
7.0	109.23	42.33	109.64	40.77	110.06	40.09	110.47	40.32	110.88	41.46
7.1	111.17	42.22	111.59	40.62	112.00	39.89	112.41	40.09	112.83	41.19
7.2	113.12	42.12	113.53	40.48	113.94	39.71	114.36	39.87	114.77	40.94
7.3	115.06	42.03	115.47	40.34	115.89	39.53	116.30	39.65	116.71	40.69
7.4	117.00	41.95	117.42	40.22	117.83	39.37	118.24	39.45	118.66	40.46
7.5	118.95	41.87	119.36	40.11	119.77	39.21	120.19	39.25	120.60	40.23
7.6	120.89	41.81	121.30	40.00	121.72	39.07	122.13	39.07	122.54	40.01
7.7	122.83	41.76	123.25	39.91	123.66	38.93	124.07	38.89	124.49	39.80
7.8	124.78	41.72	125.19	39.83	125.60	38.81	126.02	38.73	126.43	39.60
7.9	126.72	41.68	127.13	39.75	127.55	38.69	127.96	38.57	128.37	39.41
8.0	128.66	41.66	129.08	39.69	129.49	38.59	129.90	38.43	130.32	39.23
8.1	130.61	41.65	131.02	39.64	131.43	38.49	131.85	38.29	132.26	39.06
8.2	132.55	41.65	132.96	39.59	133.38	38.41	133.79	38.17	134.21	38.89
8.3	134.49	41.65	134.91	39.56	135.32	38.33	135.73	38.05	136.15	38.74
8.4	136.44	41.67	136.85	39.54	137.26	38.27	137.68	37.95	138.09	38.60
8.5	138.38	41.70	138.79	39.53	139.21	38.22	139.62	37.86	140.04	38.47
8.6	140.32	41.73	140.74	39.53	141.15	38.18	141.56	37.78	141.98	38.35
8.7	142.27	41.78	142.68	39.54	143.09	38.15	143.51	37.70	143.92	38.24
8.8	144.21	41.83	144.62	39.56	145.04	38.13	145.45	37.64	145.87	38.13
8.9	146.15	41.90	146.57	39.59	146.98	38.12	147.39	37.59	147.81	38.04
9.0	148.10	41.98	148.51	39.63	148.92	38.12	149.34	37.55	149.75	37.97
9.1	150.04	42.06	150.45	39.68	150.87	38.14	151.28	37.53	151.70	37.90
9.2	151.98	42.16	152.40	39.74	152.81	38.16	153.23	37.51	153.64	37.84
9.3	153.93	42.26	154.34	39.82	154.75	38.19	155.17	37.50	155.58	37.79
9.4	155.87	42.37	156.28	39.90	156.70	38.24	157.11	37.51	157.53	37.76
9.5	157.81	42.50	158.23	39.99	158.64	38.29	159.06	37.52	159.47	37.73
9.6	159.76	42.63	160.17	40.09	160.58	38.36	161.00	37.55	161.41	37.72
9.7	161.70	42.77	162.11	40.20	162.53	38.44	162.94	37.59	163.36	37.71
9.8	163.64	42.92	164.06	40.33	164.47	38.53	164.89	37.64	165.30	37.72
9.9	165.59	43.08	166.00	40.46	166.41	38.62	166.83	37.70	167.24	37.74
10.0	167.53	43.25	167.94	40.60	168.36	38.73	168.77	37.77	169.19	37.77
10.1	169.47	43.43	169.89	40.75	170.30	38.85	170.72	37.85	171.13	37.81
10.2	171.42	43.62	171.83	40.91	172.25	38.98	172.66	37.94	173.07	37.86
10.3	173.36	43.81	173.77	41.08	174.19	39.12	174.60	38.04	175.02	37.92
10.4	175.30	44.01	175.72	41.26	176.13	39.27	176.55	38.15	176.96	37.99
10.5	177.25	44.23	177.66	41.45	178.08	39.43	178.49	38.28	178.90	38.08
11.0	186.96	45.41	187.38	42.53	187.79	40.37	188.21	39.05	188.62	38.65
11.5								ORD 9 =	198.75	39.83

CONTINUED . . .

APPENDIX 9 CONTINUED

1964 TREE 2 TSCN = Y = -63.246 + 13.002X1 + 7.663X2

X1 = RH2	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	45.42	41.35	53.08	37.95	60.75	35.92	68.41	35.48	76.07	36.70
6.2	48.02	41.02	55.68	37.53	63.35	35.41	71.01	34.90	78.67	36.07
6.4	50.62	40.71	58.28	37.14	65.95	34.93	73.61	34.34	81.27	35.47
6.6	53.22	40.44	60.88	36.77	68.55	34.47	76.21	33.82	83.87	34.90
6.8	55.82	40.19	63.48	36.44	71.15	34.05	78.81	33.32	86.47	34.35
7.0	58.42	39.98	66.09	36.14	73.75	33.67	81.41	32.86	89.07	33.83
7.1	59.72	39.88	67.39	36.00	75.05	33.48	82.71	32.64	90.37	33.59
7.2	61.02	39.79	68.69	35.87	76.35	33.31	84.01	32.42	91.67	33.35
7.3	62.32	39.71	69.99	35.75	77.65	33.15	85.31	32.22	92.97	33.11
7.4	63.62	39.64	71.29	35.64	78.95	32.99	86.61	32.02	94.28	32.89
7.5	64.92	39.57	72.59	35.54	80.25	32.84	87.91	31.84	95.58	32.67
7.6	66.22	39.52	73.89	35.44	81.55	32.71	89.21	31.66	96.88	32.47
7.7	67.52	39.47	75.19	35.36	82.85	32.58	90.51	31.49	98.18	32.27
7.8	68.82	39.43	76.49	35.28	84.15	32.46	91.81	31.33	99.48	32.08
7.9	70.12	39.39	77.79	35.21	85.45	32.35	93.11	31.18	100.78	31.90
8.0	71.42	39.37	79.09	35.15	86.75	32.25	94.41	31.04	102.08	31.72
8.1	72.72	39.35	80.39	35.10	88.05	32.16	95.71	30.91	103.38	31.56
8.2	74.03	39.34	81.69	35.05	89.35	32.08	97.01	30.79	104.68	31.40
8.3	75.33	39.34	82.99	35.02	90.65	32.01	98.31	30.68	105.98	31.26
8.4	76.63	39.35	84.29	35.00	91.95	31.94	99.61	30.58	107.28	31.12
8.5	77.93	39.36	85.59	34.98	93.25	31.89	100.91	30.49	108.58	31.00
8.6	79.23	39.39	86.89	34.98	94.55	31.85	102.21	30.41	109.88	30.88
8.7	80.53	39.42	88.19	34.98	95.85	31.82	103.52	30.34	111.18	30.78
8.8	81.83	39.46	89.49	34.99	97.15	31.80	104.82	30.28	112.48	30.68
8.9	83.13	39.51	90.79	35.01	98.45	31.78	106.12	30.23	113.78	30.59
9.0	84.43	39.56	92.09	35.04	99.75	31.78	107.42	30.19	115.08	30.52
9.1	85.73	39.62	93.39	35.08	101.05	31.79	108.72	30.16	116.38	30.45
9.2	87.03	39.69	94.69	35.13	102.35	31.81	110.02	30.14	117.68	30.40
9.3	88.33	39.77	95.99	35.19	103.65	31.84	111.32	30.13	118.98	30.35
9.4	89.63	39.86	97.29	35.25	104.95	31.87	112.62	30.13	120.28	30.32
9.5	90.93	39.96	98.59	35.33	106.25	31.92	113.92	30.15	121.58	30.29
9.6	92.23	40.06	99.89	35.41	107.55	31.98	115.22	30.17	122.88	30.28
9.7	93.53	40.17	101.19	35.51	108.85	32.05	116.52	30.20	124.18	30.27
9.8	94.83	40.28	102.49	35.61	110.15	32.12	117.82	30.25	125.48	30.28
9.9	96.13	40.41	103.79	35.72	111.45	32.21	119.12	30.30	126.78	30.30
10.0	97.43	40.54	105.09	35.83	112.76	32.31	120.42	30.37	128.08	30.33
10.1	98.73	40.68	106.39	35.96	114.06	32.41	121.72	30.44	129.38	30.37
10.2	100.03	40.83	107.69	36.10	115.36	32.53	123.02	30.53	130.68	30.42
10.3	101.33	40.98	108.99	36.24	116.66	32.65	124.32	30.62	131.98	30.47
10.4	102.63	41.15	110.29	36.39	117.96	32.78	125.62	30.73	133.28	30.54
10.5	103.93	41.31	111.59	36.55	119.26	32.93	126.92	30.85	134.58	30.62
11.0	110.43	42.26	118.09	37.47	125.76	33.77	133.42	31.57	141.08	31.17
11.5								ORD 9 =	155.25	33.23

CONTINUED . . .

APPENDIX 9 CONTINUED

1964 TREE 3 TSCN = Y = -46.906 + 12.096X1 + 10.382X2

X1 = RH2	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	67.20	37.43	77.58	33.04	87.96	30.14	98.34	29.15	108.72	30.28
6.2	69.62	36.97	80.00	32.50	90.38	29.51	100.76	28.48	111.14	29.60
6.4	72.03	36.54	82.42	31.98	92.80	28.92	103.18	27.83	113.56	28.95
6.6	74.45	36.14	84.84	31.50	95.22	28.35	105.60	27.22	115.98	28.33
6.8	76.87	35.77	87.25	31.05	97.64	27.82	108.02	26.63	118.40	27.75
7.0	79.29	35.43	89.67	30.63	100.06	27.32	110.44	26.08	120.82	27.19
7.1	80.50	35.27	90.88	30.43	101.27	27.09	111.65	25.82	122.03	26.93
7.2	81.71	35.12	92.09	30.25	102.47	26.87	112.86	25.57	123.24	26.67
7.3	82.92	34.98	93.30	30.07	103.68	26.65	114.07	25.33	124.45	26.42
7.4	84.13	34.84	94.51	29.90	104.89	26.44	115.28	25.10	125.66	26.19
7.5	85.34	34.72	95.72	29.74	106.10	26.25	116.49	24.88	126.87	25.96
7.6	86.55	34.60	96.93	29.59	107.31	26.06	117.70	24.66	128.08	25.74
7.7	87.76	34.49	98.14	29.45	108.52	25.89	118.90	24.46	129.29	25.53
7.8	88.97	34.40	99.35	29.32	109.73	25.73	120.11	24.27	130.50	25.34
7.9	90.18	34.30	100.56	29.20	110.94	25.57	121.32	24.10	131.71	25.15
8.0	91.39	34.22	101.77	29.09	112.15	25.43	122.53	23.93	132.92	24.97
8.1	92.60	34.15	102.98	28.99	113.36	25.30	123.74	23.78	134.13	24.81
8.2	93.81	34.09	104.19	28.90	114.57	25.19	124.95	23.63	135.33	24.66
8.3	95.02	34.03	105.40	28.82	115.78	25.08	126.16	23.50	136.54	24.52
8.4	96.23	33.98	106.61	28.76	116.99	24.99	127.37	23.39	137.75	24.39
8.5	97.43	33.95	107.82	28.70	118.20	24.90	128.58	23.28	138.96	24.27
8.6	98.64	33.92	109.03	28.65	119.41	24.83	129.79	23.19	140.17	24.17
8.7	99.85	33.90	110.24	28.62	120.62	24.78	131.00	23.11	141.38	24.08
8.8	101.06	33.89	111.45	28.59	121.83	24.73	132.21	23.04	142.59	24.00
8.9	102.27	33.89	112.66	28.58	123.04	24.70	133.42	22.99	143.80	23.93
9.0	103.48	33.90	113.86	28.57	124.25	24.68	134.63	22.95	145.01	23.87
9.1	104.69	33.91	115.07	28.58	125.46	24.67	135.84	22.93	146.22	23.83
9.2	105.90	33.94	116.28	28.60	126.67	24.67	137.05	22.91	147.43	23.80
9.3	107.11	33.98	117.49	28.62	127.88	24.69	138.26	22.91	148.64	23.79
9.4	108.32	34.02	118.70	28.66	129.09	24.72	139.47	22.93	149.85	23.79
9.5	109.53	34.07	119.91	28.71	130.29	24.76	140.68	22.96	151.06	23.80
9.6	110.74	34.14	121.12	28.77	131.50	24.82	141.89	23.00	152.27	23.82
9.7	111.95	34.21	122.33	28.85	132.71	24.88	143.10	23.05	153.48	23.86
9.8	113.16	34.29	123.54	28.93	133.92	24.96	144.31	23.12	154.69	23.91
9.9	114.37	34.38	124.75	29.02	135.13	25.05	145.52	23.20	155.90	23.97
10.0	115.58	34.48	125.96	29.12	136.34	25.15	146.72	23.30	157.11	24.04
10.1	116.79	34.58	127.17	29.23	137.55	25.27	147.93	23.40	158.32	24.13
10.2	118.00	34.70	128.38	29.36	138.76	25.40	149.14	23.52	159.53	24.23
10.3	119.21	34.82	129.59	29.49	139.97	25.53	150.35	23.66	160.74	24.34
10.4	120.42	34.95	130.80	29.63	141.18	25.68	151.56	23.80	161.95	24.47
10.5	121.63	35.10	132.01	29.78	142.39	25.84	152.77	23.96	163.15	24.60
11.0	127.67	35.92	138.06	30.69	148.44	26.80	158.82	24.91	169.20	25.45
11.5								ORD 9 =	185.63	29.24

CONTINUED . . .

APPENDIX 9 CONTINUED

1964 TREE 4 TSCN = Y = -20.531 + 10.089X1 + 8.971X2

X1 = RH2	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	75.88	34.04	84.86	33.54	93.83	33.37	102.80	33.51	111.77	33.96
6.2	77.90	34.02	86.87	33.50	95.84	33.30	104.81	33.42	113.79	33.85
6.4	79.92	34.00	88.89	33.47	97.86	33.24	106.83	33.34	115.80	33.75
6.6	81.94	34.00	90.91	33.44	99.88	33.19	108.85	33.26	117.82	33.65
6.8	83.96	34.00	92.93	33.41	101.90	33.14	110.87	33.19	119.84	33.56
7.0	85.97	34.00	94.94	33.40	103.91	33.10	112.89	33.13	121.86	33.48
7.1	86.98	34.01	95.95	33.39	104.92	33.09	113.89	33.10	122.86	33.44
7.2	87.99	34.01	96.96	33.39	105.93	33.07	114.90	33.08	123.87	33.40
7.3	89.00	34.02	97.97	33.39	106.94	33.06	115.91	33.05	124.88	33.37
7.4	90.01	34.03	98.98	33.38	107.95	33.05	116.92	33.03	125.89	33.33
7.5	91.02	34.05	99.99	33.39	108.96	33.04	117.93	33.01	126.90	33.30
7.6	92.03	34.06	101.00	33.39	109.97	33.03	118.94	32.99	127.91	33.27
7.7	93.04	34.08	102.01	33.39	110.98	33.02	119.95	32.97	128.92	33.24
7.8	94.04	34.09	103.02	33.40	111.99	33.02	120.96	32.95	129.93	33.21
7.9	95.05	34.11	104.02	33.41	112.99	33.01	121.97	32.94	130.94	33.19
8.0	96.06	34.13	105.03	33.42	114.00	33.01	122.97	32.93	131.94	33.16
8.1	97.07	34.15	106.04	33.43	115.01	33.01	123.98	32.91	132.95	33.14
8.2	98.08	34.18	107.05	33.44	116.02	33.01	124.99	32.90	133.96	33.12
8.3	99.09	34.20	108.06	33.46	117.03	33.02	126.00	32.90	134.97	33.10
8.4	100.10	34.23	109.07	33.47	118.04	33.02	127.01	32.89	135.98	33.08
8.5	101.11	34.26	110.08	33.49	119.05	33.03	128.02	32.89	136.99	33.07
8.6	102.12	34.29	111.09	33.51	120.06	33.04	129.03	32.88	138.00	33.05
8.7	103.12	34.32	112.09	33.53	121.07	33.05	130.04	32.88	139.01	33.04
8.8	104.13	34.35	113.10	33.55	122.07	33.06	131.05	32.88	140.02	33.03
8.9	105.14	34.39	114.11	33.58	123.08	33.07	132.05	32.88	141.02	33.02
9.0	106.15	34.42	115.12	33.60	124.09	33.09	133.06	32.89	142.03	33.01
9.1	107.16	34.46	116.13	33.63	125.10	33.10	134.07	32.89	143.04	33.01
9.2	108.17	34.50	117.14	33.66	126.11	33.12	135.08	32.90	144.05	33.00
9.3	109.18	34.54	118.15	33.69	127.12	33.14	136.09	32.91	145.06	33.00
9.4	110.19	34.59	119.16	33.73	128.13	33.17	137.10	32.92	146.07	33.00
9.5	111.20	34.63	120.17	33.76	129.14	33.19	138.11	32.93	147.08	33.00
9.6	112.20	34.68	121.17	33.80	130.15	33.21	139.12	32.95	148.09	33.00
9.7	113.21	34.72	122.18	33.83	131.15	33.24	140.13	32.96	149.10	33.01
9.8	114.22	34.77	123.19	33.87	132.16	33.27	141.13	32.98	150.10	33.01
9.9	115.23	34.82	124.20	33.91	133.17	33.30	142.14	33.00	151.11	33.02
10.0	116.24	34.88	125.21	33.96	134.18	33.33	143.15	33.02	152.12	33.03
10.1	117.25	34.93	126.22	34.00	135.19	33.37	144.16	33.04	153.13	33.04
10.2	118.26	34.99	127.23	34.05	136.20	33.40	145.17	33.07	154.14	33.06
10.3	119.27	35.04	128.24	34.09	137.21	33.44	146.18	33.09	155.15	33.07
10.4	120.28	35.10	129.25	34.14	138.22	33.48	147.19	33.12	156.16	33.09
10.5	121.28	35.16	130.25	34.19	139.23	33.52	148.20	33.15	157.17	33.11
11.0	126.33	35.48	135.30	34.47	144.27	33.74	153.24	33.32	162.21	33.22
11.5								ORD 9 =	176.23	33.54

CONTINUED . . .

1964 TREE 5 TSCN = Y = -23.995 + 18.848X1

VARIABLE ORD NEGATIVE AND NON-SIGNIFICANT, THEREFORE EXCLUDED FROM EQUATION

X1 = RH2	Y	+-
6.0	89.09	44.53
6.2	92.86	44.11
6.4	96.63	43.70
6.6	100.40	43.33
6.8	104.17	42.97
7.0	107.94	42.64
7.1	109.83	42.48
7.2	111.71	42.33
7.3	113.60	42.19
7.4	115.48	42.05
7.5	117.37	41.92
7.6	119.25	41.80
7.7	121.14	41.68
7.8	123.02	41.57
7.9	124.91	41.47
8.0	126.79	41.37
8.1	128.67	41.28
8.2	130.56	41.20
8.3	132.44	41.12
8.4	134.33	41.05
8.5	136.21	40.99
8.6	138.10	40.94
8.7	139.98	40.89
8.8	141.87	40.85
8.9	143.75	40.82
9.0	145.64	40.79
9.1	147.52	40.77
9.2	149.41	40.76
9.3	151.29	40.76
9.4	153.18	40.76
9.5	155.06	40.77
9.6	156.95	40.79
9.7	158.83	40.81
9.8	160.72	40.84
9.9	162.60	40.88
10.0	164.49	40.93
10.1	166.37	40.98
10.2	168.26	41.04
10.3	170.14	41.11
10.4	172.03	41.18
10.5	173.91	41.26
11.0	183.33	41.77
11.5	192.76	42.45

CONTINUED . . .

APPENDIX 9 CONTINUED

1964 TREE 6 TSCN = Y = 57.647 + 9.176X1

VARIABLE ORD NEGATIVE AND NON-SIGNIFICANT, THEREFORE EXCLUDED FROM EQUATION

X1 = RH1	Y	+-
5.0	103.53	75.17
5.5	108.12	66.66
6.0	112.71	58.27
6.5	117.29	50.04
7.0	121.88	42.09
7.5	126.47	34.58
8.0	131.06	27.91
8.5	135.65	22.79
9.0	140.24	20.45
9.5	144.82	21.79
10.0	149.41	26.25
10.5	154.00	32.58

CONTINUED . . .

APPENDIX 9 CONTINUED

1964 TREE 7 TSCN = Y = -90.872 + 13.641X1 + 13.041X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	43.14	21.69	56.18	20.86	69.22	20.65	82.26	21.08	95.31	22.12
6.2	45.87	21.41	58.91	20.51	71.95	20.23	84.99	20.62	98.03	21.62
6.4	48.60	21.15	61.64	20.18	74.68	19.84	87.72	20.17	100.76	21.13
6.6	51.33	20.92	64.37	19.87	77.41	19.46	90.45	19.74	103.49	20.66
6.8	54.05	20.71	67.10	19.59	80.14	19.11	93.18	19.33	106.22	20.21
7.0	56.78	20.53	69.82	19.33	82.86	18.78	95.91	18.94	108.95	19.78
7.1	58.15	20.45	71.19	19.21	84.23	18.63	97.27	18.75	110.31	19.57
7.2	59.51	20.37	72.55	19.10	85.59	18.48	98.63	18.58	111.67	19.37
7.3	60.87	20.31	73.92	19.00	86.96	18.34	100.00	18.40	113.04	19.17
7.4	62.24	20.25	75.28	18.90	88.32	18.21	101.36	18.24	114.40	18.98
7.5	63.60	20.19	76.64	18.82	89.69	18.08	102.73	18.08	115.77	18.80
7.6	64.97	20.15	78.01	18.73	91.05	17.96	104.09	17.92	117.13	18.62
7.7	66.33	20.11	79.37	18.66	92.41	17.85	105.45	17.78	118.50	18.44
7.8	67.70	20.08	80.74	18.59	93.78	17.75	106.82	17.64	119.86	18.27
7.9	69.06	20.05	82.10	18.53	95.14	17.65	108.18	17.51	121.22	18.11
8.0	70.42	20.04	83.46	18.48	96.51	17.56	109.55	17.38	122.59	17.96
8.1	71.79	20.03	84.83	18.44	97.87	17.48	110.91	17.27	123.95	17.81
8.2	73.15	20.03	86.19	18.40	99.23	17.41	112.28	17.16	125.32	17.67
8.3	74.52	20.03	87.56	18.38	100.60	17.35	113.64	17.06	126.68	17.54
8.4	75.88	20.04	88.92	18.36	101.96	17.29	115.00	16.96	128.04	17.41
8.5	77.24	20.06	90.29	18.35	103.33	17.24	116.37	16.88	129.41	17.30
8.6	78.61	20.09	91.65	18.34	104.69	17.20	117.73	16.80	130.77	17.19
8.7	79.97	20.12	93.01	18.35	106.05	17.17	119.10	16.73	132.14	17.08
8.8	81.34	20.16	94.38	18.36	107.42	17.15	120.46	16.67	133.50	16.99
8.9	82.70	20.21	95.74	18.38	108.78	17.14	121.82	16.62	134.87	16.90
9.0	84.06	20.27	97.11	18.41	110.15	17.13	123.19	16.58	136.23	16.83
9.1	85.43	20.33	98.47	18.44	111.51	17.13	124.55	16.55	137.59	16.76
9.2	86.79	20.40	99.83	18.49	112.88	17.15	125.92	16.52	138.96	16.69
9.3	88.16	20.48	101.20	18.54	114.24	17.17	127.28	16.51	140.32	16.64
9.4	89.52	20.56	102.56	18.60	115.60	17.19	128.64	16.50	141.69	16.60
9.5	90.89	20.65	103.93	18.66	116.97	17.23	130.01	16.50	143.05	16.56
9.6	92.25	20.75	105.29	18.74	118.33	17.28	131.37	16.51	144.41	16.54
9.7	93.61	20.85	106.66	18.82	119.70	17.33	132.74	16.53	145.78	16.52
9.8	94.98	20.96	108.02	18.91	121.06	17.39	134.10	16.56	147.14	16.51
9.9	96.34	21.08	109.38	19.01	122.42	17.46	135.47	16.59	148.51	16.51
10.0	97.71	21.20	110.75	19.11	123.79	17.54	136.83	16.64	149.87	16.52
10.1	99.07	21.33	112.11	19.22	125.15	17.63	138.19	16.69	151.23	16.54
10.2	100.43	21.46	113.48	19.34	126.52	17.72	139.56	16.76	152.60	16.56
10.3	101.80	21.60	114.84	19.46	127.88	17.82	140.92	16.83	153.96	16.60
10.4	103.16	21.75	116.20	19.60	129.25	17.93	142.29	16.91	155.33	16.64
10.5	104.53	21.90	117.57	19.73	130.61	18.05	143.65	17.00	156.69	16.70
11.0	111.35	22.75	124.39	20.52	137.43	18.74	150.47	17.55	163.51	17.09
11.5								ORD 9 =	183.37	17.80

CONTINUED . . .

APPENDIX 9 CONTINUED

1964 TREE 8 TSCN = Y = -8.997 + 6.857X1 + 7.362X2

X1 = RH3	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
4.0	47.88	43.55	55.24	43.24	62.60	44.34	69.97	46.75	77.33	50.28
5.0	54.74	38.04	62.10	36.89	69.46	37.39	76.82	39.47	84.19	42.91
5.5	58.16	35.58	65.53	33.91	72.89	34.02	80.25	35.89	87.61	39.26
6.0	61.59	33.38	68.95	31.12	76.32	30.76	83.68	32.36	91.04	35.65
6.2	62.96	32.59	70.33	30.07	77.69	29.50	85.05	30.96	92.41	34.21
6.3	63.65	32.21	71.01	29.56	78.37	28.87	85.74	30.27	93.10	33.50
6.4	64.34	31.84	71.70	29.06	79.06	28.26	86.42	29.59	93.78	32.79
6.5	65.02	31.49	72.38	28.57	79.75	27.65	87.11	28.90	94.47	32.08
6.6	65.71	31.16	73.07	28.10	80.43	27.05	87.79	28.22	95.16	31.38
6.7	66.39	30.84	73.75	27.64	81.12	26.45	88.48	27.55	95.84	30.68
6.8	67.08	30.53	74.44	27.19	81.80	25.87	89.16	26.88	96.53	29.98
6.9	67.76	30.25	75.13	26.75	82.49	25.29	89.85	26.21	97.21	29.28
7.0	68.45	29.97	75.81	26.33	83.17	24.73	90.54	25.55	97.90	28.59
7.1	69.13	29.72	76.50	25.93	83.86	24.18	91.22	24.90	98.58	27.90
7.2	69.82	29.48	77.18	25.54	84.55	23.64	91.91	24.25	99.27	27.21
7.3	70.51	29.27	77.87	25.17	85.23	23.11	92.59	23.61	99.96	26.53
7.4	71.19	29.07	78.55	24.82	85.92	22.59	93.28	22.98	100.64	25.85
7.5	71.88	28.88	79.24	24.49	86.60	22.09	93.96	22.35	101.33	25.18
7.6	72.56	28.72	79.93	24.17	87.29	21.61	94.65	21.74	102.01	24.52
7.7	73.25	28.58	80.61	23.88	87.97	21.14	95.34	21.13	102.70	23.86
7.8	73.93	28.46	81.30	23.61	88.66	20.69	96.02	20.53	103.38	23.20
7.9	74.62	28.36	81.98	23.36	89.34	20.25	96.71	19.95	104.07	22.56
8.0	75.31	28.27	82.67	23.13	90.03	19.84	97.39	19.38	104.76	21.92
8.1	75.99	28.21	83.35	22.93	90.72	19.45	98.08	18.82	105.44	21.29
8.2	76.68	28.17	84.04	22.74	91.40	19.08	98.76	18.28	106.13	20.67
8.3	77.36	28.15	84.73	22.59	92.09	18.74	99.45	17.75	106.81	20.05
8.4	78.05	28.15	85.41	22.46	92.77	18.42	100.14	17.24	107.50	19.45
8.5	78.73	28.17	86.10	22.35	93.46	18.13	100.82	16.75	108.18	18.86
8.6	79.42	28.21	86.78	22.27	94.14	17.86	101.51	16.28	108.87	18.29
8.7	80.11	28.28	87.47	22.22	94.83	17.62	102.19	15.84	109.55	17.72
8.8	80.79	28.36	88.15	22.19	95.52	17.42	102.88	15.42	110.24	17.18
8.9	81.48	28.46	88.84	22.19	96.20	17.25	103.56	15.02	110.93	16.65
9.0	82.16	28.58	89.52	22.21	96.89	17.10	104.25	14.66	111.61	16.14
9.1	82.85	28.73	90.21	22.26	97.57	17.00	104.94	14.33	112.30	15.65
9.2	83.53	28.89	90.90	22.34	98.26	16.92	105.62	14.03	112.98	15.18
9.3	84.22	29.07	91.58	22.44	98.94	16.88	106.31	13.77	113.67	14.74
9.4	84.91	29.27	92.27	22.57	99.63	16.88	106.99	13.54	114.35	14.32
9.5	85.59	29.49	92.95	22.72	100.32	16.90	107.68	13.36	115.04	13.94
9.6	86.28	29.73	93.64	22.90	101.00	16.97	108.36	13.22	115.73	13.58
9.7	86.96	29.98	94.32	23.10	101.69	17.07	109.05	13.12	116.41	13.26
9.8	87.65	30.25	95.01	23.32	102.37	17.20	109.73	13.06	117.10	12.98
9.9	88.33	30.54	95.70	23.57	103.06	17.36	110.42	13.05	117.78	12.74
10.0	89.02	30.85	96.38	23.84	103.74	17.56	111.11	13.08	'118.47	12.54

'AND ORD 9

CONTINUED . . .

APPENDIX 9 CONTINUED

1964 TREE 9 TSCN = Y = -24.270 + 10.057X1 + 8.590X2

X1 = RH4	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
4.5	55.34	36.83	63.93	33.99	72.52	32.31	81.11	31.97	89.70	33.01
5.0	60.37	35.16	68.96	32.11	77.55	30.25	86.14	29.82	94.73	30.87
5.5	65.40	33.62	73.99	30.34	82.58	28.30	91.17	27.76	99.76	28.82
6.0	70.43	32.22	79.02	28.72	87.61	26.47	96.20	25.82	104.79	26.88
6.5	75.46	30.99	84.05	27.26	92.64	24.80	101.23	24.02	109.82	25.07
6.6	76.46	30.77	85.05	26.99	93.64	24.49	102.23	23.68	110.82	24.72
6.7	77.47	30.55	86.06	26.72	94.65	24.18	103.24	23.34	111.83	24.39
6.8	78.48	30.34	87.07	26.47	95.65	23.88	104.24	23.02	112.83	24.06
6.9	79.48	30.14	88.07	26.23	96.66	23.59	105.25	22.70	113.84	23.74
7.0	80.49	29.95	89.08	25.99	97.67	23.31	106.26	22.39	114.85	23.43
7.1	81.49	29.77	90.08	25.76	98.67	23.04	107.26	22.09	115.85	23.12
7.2	82.50	29.59	91.09	25.54	99.68	22.78	108.27	21.80	116.86	22.82
7.3	83.50	29.43	92.09	25.33	100.68	22.53	109.27	21.51	117.86	22.54
7.4	84.51	29.27	93.10	25.13	101.69	22.28	110.28	21.24	118.87	22.26
7.5	85.52	29.12	94.10	24.94	102.69	22.05	111.28	20.98	119.87	21.99
7.6	86.52	28.98	95.11	24.77	103.70	21.83	112.29	20.72	120.88	21.73
7.7	87.53	28.85	96.12	24.60	104.71	21.62	113.30	20.48	121.89	21.48
7.8	88.53	28.73	97.12	24.44	105.71	21.42	114.30	20.25	122.89	21.24
7.9	89.54	28.62	98.13	24.29	106.72	21.23	115.31	20.03	123.90	21.01
8.0	90.54	28.51	99.13	24.15	107.72	21.05	116.31	19.82	124.90	20.79
8.1	91.55	28.42	100.14	24.03	108.73	20.89	117.32	19.63	125.91	20.59
8.2	92.56	28.34	101.14	23.91	109.73	20.74	118.32	19.45	126.91	20.39
8.3	93.56	28.27	102.15	23.81	110.74	20.60	119.33	19.28	127.92	20.21
8.4	94.57	28.20	103.16	23.72	111.75	20.48	120.34	19.12	128.92	20.04
8.5	95.57	28.15	104.16	23.64	112.75	20.36	121.34	18.98	129.93	19.89
8.6	96.58	28.11	105.17	23.57	113.76	20.26	122.35	18.85	130.94	19.75
8.7	97.58	28.08	106.17	23.51	114.76	20.18	123.35	18.74	131.94	19.62
8.8	98.59	28.05	107.18	23.47	115.77	20.11	124.36	18.64	132.95	19.50
8.9	99.59	28.04	108.18	23.44	116.77	20.05	125.36	18.56	133.95	19.40
9.0	100.60	28.04	109.19	23.42	117.78	20.01	126.37	18.49	134.96	19.31
9.1	101.61	28.05	110.20	23.41	118.79	19.98	127.38	18.43	135.96	19.24
9.2	102.61	28.07	111.20	23.42	119.79	19.96	128.38	18.40	136.97	19.18
9.3	103.62	28.10	112.21	23.43	120.80	19.96	129.39	18.37	137.98	19.14
9.4	104.62	28.13	113.21	23.46	121.80	19.98	130.39	18.37	138.98	19.11
9.5	105.63	28.18	114.22	23.50	122.81	20.00	131.40	18.37	139.99	19.10
9.6	106.63	28.24	115.22	23.56	123.81	20.05	132.40	18.40	140.99	19.10
9.7	107.64	28.31	116.23	23.62	124.82	20.10	133.41	18.44	142.00	19.12
9.8	108.65	28.39	117.24	23.70	125.83	20.17	134.41	18.49	143.00	19.15
9.9	109.65	28.48	118.24	23.79	126.83	20.26	135.42	18.56	144.01	19.20
10.0	110.66	28.58	119.25	23.89	127.84	20.35	136.43	18.65	145.02	19.26
10.1	111.66	28.68	120.25	24.00	128.84	20.47	137.43	18.75	146.02	19.33
10.2	112.67	28.80	121.26	24.12	129.85	20.59	138.44	18.86	147.03	19.42
10.5	115.69	29.21	124.28	24.56	132.87	21.04	141.45	19.29	150.04	19.78
10.8								ORD 9 =	161.65	22.73

CONTINUED . . .

APPENDIX 9 CONTINUED

1964 TREE 10 TSCN = Y =-154.409 + 9.970X1 + 24.100X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	1.81	29.88	25.91	27.48	50.01	29.28	74.11	34.62	98.21	42.18
6.2	3.81	29.38	27.91	26.43	52.00	27.81	76.10	32.99	100.20	40.52
6.4	5.80	28.97	29.90	25.46	54.00	26.39	78.10	31.37	102.20	38.87
6.6	7.79	28.66	31.89	24.57	55.99	25.00	80.09	29.76	104.19	37.23
6.8	9.79	28.46	33.89	23.77	57.99	23.66	82.09	28.18	106.19	35.60
7.0	11.78	28.37	35.88	23.09	59.98	22.38	84.08	26.61	108.18	33.98
7.1	12.78	28.36	36.88	22.78	60.98	21.76	85.08	25.83	109.18	33.18
7.2	13.78	28.38	37.88	22.51	61.98	21.16	86.07	25.07	110.17	32.38
7.3	14.77	28.42	38.87	22.27	62.97	20.58	87.07	24.31	111.17	31.58
7.4	15.77	28.49	39.87	22.06	63.97	20.02	88.07	23.55	112.17	30.79
7.5	16.77	28.59	40.87	21.88	64.97	19.49	89.07	22.81	113.17	30.00
7.6	17.76	28.72	41.86	21.74	65.96	18.98	90.06	22.07	114.16	29.22
7.7	18.76	28.87	42.86	21.63	66.96	18.50	91.06	21.35	115.16	28.44
7.8	19.76	29.05	43.86	21.56	67.96	18.04	92.06	20.63	116.16	27.66
7.9	20.75	29.25	44.85	21.52	68.95	17.62	93.05	19.93	117.15	26.90
8.0	21.75	29.47	45.85	21.52	69.95	17.23	94.05	19.24	118.15	26.14
8.1	22.75	29.72	46.85	21.55	70.95	16.88	95.05	18.57	119.15	25.39
8.2	23.75	30.00	47.85	21.62	71.95	16.57	96.05	17.92	120.14	24.64
8.3	24.74	30.29	48.84	21.72	72.94	16.30	97.04	17.28	121.14	23.90
8.4	25.74	30.61	49.84	21.86	73.94	16.07	98.04	16.67	122.14	23.18
8.5	26.74	30.95	50.84	22.03	74.94	15.88	99.04	16.08	123.14	22.46
8.6	27.73	31.31	51.83	22.24	75.93	15.75	100.03	15.52	124.13	21.76
8.7	28.73	31.69	52.83	22.47	76.93	15.66	101.03	14.99	125.13	21.07
8.8	29.73	32.09	53.83	22.74	77.93	15.61	102.03	14.49	126.13	20.39
8.9	30.72	32.51	54.82	23.04	78.92	15.62	103.02	14.03	127.12	19.73
9.0	31.72	32.94	55.82	23.36	79.92	15.68	104.02	13.61	128.12	19.08
9.1	32.72	33.40	56.82	23.72	80.92	15.78	105.02	13.23	129.12	18.45
9.2	33.72	33.87	57.82	24.10	81.92	15.93	106.02	12.90	130.12	17.85
9.3	34.71	34.35	58.81	24.50	82.91	16.13	107.01	12.62	131.11	17.26
9.4	35.71	34.85	59.81	24.93	83.91	16.37	108.01	12.40	132.11	16.71
9.5	36.71	35.37	60.81	25.38	84.91	16.65	109.01	12.24	133.11	16.18
9.6	37.70	35.90	61.80	25.86	85.90	16.98	110.00	12.13	134.10	15.68
9.7	38.70	36.44	62.80	26.35	86.90	17.34	111.00	12.09	135.10	15.21
9.8	39.70	36.99	63.80	26.87	87.90	17.73	112.00	12.11	136.10	14.78
9.9	40.70	37.56	64.79	27.40	88.89	18.16	112.99	12.20	137.09	14.39
10.0	41.69	38.14	65.79	27.95	89.89	18.63	113.99	12.35	138.09	14.05
10.1	42.69	38.73	66.79	28.51	90.89	19.12	114.99	12.55	139.09	13.75
10.2	43.69	39.33	67.79	29.09	91.89	19.63	115.99	12.81	140.09	13.50
10.3	44.68	39.94	68.78	29.69	92.88	20.18	116.98	13.13	141.08	13.31
10.4	45.68	40.56	69.78	30.29	93.88	20.74	117.98	13.49	142.08	13.17
10.5	46.68	41.19	70.78	30.92	94.88	21.33	118.98	13.90	143.08	13.09
11.0	51.66	44.45	75.76	34.19	99.86	24.51	123.96	16.50	148.06	13.54
11.5								ORD 9 =	177.15	17.80

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 1 TSCN = Y = -26.465 + 13.636X1 + 9.558X2

X1 = RH2	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	93.58	33.25	103.14	32.75	112.70	32.69	122.26	33.07	131.81	33.87
6.2	96.31	33.15	105.87	32.61	115.42	32.51	124.98	32.86	134.54	33.63
6.4	99.04	33.06	108.59	32.49	118.15	32.35	127.71	32.66	137.27	33.40
6.6	101.76	32.99	111.32	32.38	120.88	32.20	130.44	32.48	139.99	33.19
6.8	104.49	32.93	114.05	32.28	123.61	32.07	133.16	32.31	142.72	32.99
7.0	107.22	32.89	116.78	32.20	126.33	31.95	135.89	32.15	145.45	32.80
7.1	108.58	32.87	118.14	32.16	127.70	31.90	137.25	32.08	146.81	32.71
7.2	109.94	32.86	119.50	32.13	129.06	31.85	138.62	32.01	148.18	32.62
7.3	111.31	32.85	120.87	32.10	130.42	31.80	139.98	31.95	149.54	32.54
7.4	112.67	32.84	122.23	32.08	131.79	31.76	141.35	31.88	150.90	32.46
7.5	114.04	32.84	123.59	32.06	133.15	31.72	142.71	31.83	152.27	32.38
7.6	115.40	32.84	124.96	32.04	134.51	31.68	144.07	31.77	153.63	32.31
7.7	116.76	32.85	126.32	32.03	135.88	31.65	145.44	31.72	154.99	32.24
7.8	118.13	32.86	127.68	32.02	137.24	31.62	146.80	31.67	156.36	32.18
7.9	119.49	32.87	129.05	32.01	138.61	31.60	148.16	31.63	157.72	32.12
8.0	120.85	32.89	130.41	32.01	139.97	31.57	149.53	31.59	159.08	32.06
8.1	122.22	32.91	131.77	32.01	141.33	31.56	150.89	31.55	160.45	32.00
8.2	123.58	32.93	133.14	32.02	142.70	31.54	152.25	31.52	161.81	31.95
8.3	124.94	32.96	134.50	32.03	144.06	31.53	153.62	31.49	163.18	31.91
8.4	126.31	32.99	135.87	32.04	145.42	31.53	154.98	31.47	164.54	31.86
8.5	127.67	33.02	137.23	32.06	146.79	31.53	156.34	31.45	165.90	31.82
8.6	129.03	33.06	138.59	32.08	148.15	31.53	157.71	31.43	167.27	31.79
8.7	130.40	33.10	139.96	32.10	149.51	31.53	159.07	31.42	168.63	31.76
8.8	131.76	33.15	141.32	32.13	150.88	31.54	160.44	31.41	169.99	31.73
8.9	133.13	33.19	142.68	32.16	152.24	31.55	161.80	31.40	171.36	31.70
9.0	134.49	33.25	144.05	32.20	153.60	31.57	163.16	31.40	172.72	31.68
9.1	135.85	33.30	145.41	32.23	154.97	31.59	164.53	31.40	174.08	31.66
9.2	137.22	33.36	146.77	32.28	156.33	31.62	165.89	31.40	175.45	31.65
9.3	138.58	33.42	148.14	32.32	157.70	31.64	167.25	31.41	176.81	31.64
9.4	139.94	33.49	149.50	32.37	159.06	31.68	168.62	31.43	178.18	31.64
9.5	141.31	33.56	150.86	32.42	160.42	31.71	169.98	31.44	179.54	31.63
9.6	142.67	33.63	152.23	32.48	161.79	31.75	171.34	31.46	180.90	31.63
9.7	144.03	33.70	153.59	32.54	163.15	31.79	172.71	31.49	182.27	31.64
9.8	145.40	33.78	154.96	32.60	164.51	31.84	174.07	31.52	183.63	31.65
9.9	146.76	33.87	156.32	32.67	165.88	31.89	175.43	31.55	184.99	31.66
10.0	148.12	33.95	157.68	32.74	167.24	31.94	176.80	31.58	186.36	31.68
10.1	149.49	34.04	159.05	32.82	168.60	32.00	178.16	31.62	187.72	31.70
10.2	150.85	34.13	160.41	32.89	169.97	32.06	179.53	31.66	189.08	31.72
10.3	152.22	34.23	161.77	32.98	171.33	32.13	180.89	31.71	190.45	31.75
10.4	153.58	34.33	163.14	33.06	172.69	32.19	182.25	31.76	191.81	31.78
10.5	154.94	34.43	164.50	33.15	174.06	32.27	183.62	31.82	193.17	31.82
11.0	161.76	34.99	171.32	33.64	180.88	32.68	190.43	32.14	199.99	32.05
11.5								ORD 9 =	216.37	32.63

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 2 TSCN = Y = 15.300 + 9.122X1 + 4.098X2

X1 = RH4	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
4.5	72.74	29.38	76.84	28.92	80.94	28.75	85.03	28.90	89.13	29.35
5.0	77.30	29.21	81.40	28.69	85.50	28.48	89.59	28.58	93.69	29.00
5.5	81.86	29.07	85.96	28.51	90.06	28.25	94.16	28.31	98.25	28.68
6.0	86.42	28.98	90.52	28.37	94.62	28.07	98.72	28.08	102.81	28.40
6.5	90.98	28.94	95.08	28.28	99.18	27.92	103.28	27.88	107.37	28.17
6.6	91.90	28.93	95.99	28.26	100.09	27.90	104.19	27.85	108.29	28.12
6.7	92.81	28.93	96.91	28.25	101.00	27.88	105.10	27.82	109.20	28.08
6.8	93.72	28.93	97.82	28.24	101.92	27.86	106.01	27.79	110.11	28.04
6.9	94.63	28.93	98.73	28.23	102.83	27.84	106.93	27.76	111.02	28.01
7.0	95.54	28.93	99.64	28.22	103.74	27.82	107.84	27.74	111.94	27.97
7.1	96.46	28.93	100.55	28.22	104.65	27.81	108.75	27.71	112.85	27.94
7.2	97.37	28.94	101.47	28.21	105.56	27.79	109.66	27.69	113.76	27.91
7.3	98.28	28.95	102.38	28.21	106.48	27.78	110.57	27.67	114.67	27.88
7.4	99.19	28.96	103.29	28.21	107.39	27.77	111.49	27.65	115.58	27.85
7.5	100.11	28.97	104.20	28.21	108.30	27.77	112.40	27.63	116.50	27.82
7.6	101.02	28.98	105.12	28.22	109.21	27.76	113.31	27.62	117.41	27.80
7.7	101.93	28.99	106.03	28.22	110.13	27.76	114.22	27.60	118.32	27.77
7.8	102.84	29.01	106.94	28.23	111.04	27.75	115.14	27.59	119.23	27.75
7.9	103.75	29.03	107.85	28.24	111.95	27.75	116.05	27.58	120.15	27.73
8.0	104.67	29.05	108.76	28.25	112.86	27.75	116.96	27.57	121.06	27.72
8.1	105.58	29.07	109.68	28.26	113.77	27.76	117.87	27.57	121.97	27.70
8.2	106.49	29.09	110.59	28.28	114.69	27.76	118.78	27.56	122.88	27.69
8.3	107.40	29.11	111.50	28.29	115.60	27.77	119.70	27.56	123.79	27.67
8.4	108.32	29.14	112.41	28.31	116.51	27.78	120.61	27.56	124.71	27.66
8.5	109.23	29.17	113.33	28.33	117.42	27.79	121.52	27.56	125.62	27.65
8.6	110.14	29.20	114.24	28.35	118.34	27.80	122.43	27.56	126.53	27.65
8.7	111.05	29.23	115.15	28.37	119.25	27.81	123.35	27.57	127.44	27.64
8.8	111.96	29.26	116.06	28.40	120.16	27.83	124.26	27.57	128.36	27.64
8.9	112.88	29.30	116.97	28.42	121.07	27.84	125.17	27.58	129.27	27.64
9.0	113.79	29.33	117.89	28.45	121.98	27.86	126.08	27.59	130.18	27.64
9.1	114.70	29.37	118.80	28.48	122.90	27.88	126.99	27.60	131.09	27.64
9.2	115.61	29.41	119.71	28.51	123.81	27.91	127.91	27.61	132.00	27.64
9.3	116.52	29.45	120.62	28.54	124.72	27.93	128.82	27.63	132.92	27.65
9.4	117.44	29.49	121.53	28.58	125.63	27.96	129.73	27.65	133.83	27.65
9.5	118.35	29.54	122.45	28.62	126.54	27.99	130.64	27.66	134.74	27.66
9.6	119.26	29.58	123.36	28.65	127.46	28.01	131.55	27.68	135.65	27.67
9.7	120.17	29.63	124.27	28.69	128.37	28.05	132.47	27.71	136.56	27.69
9.8	121.09	29.68	125.18	28.73	129.28	28.08	133.38	27.73	137.48	27.70
9.9	122.00	29.73	126.10	28.78	130.19	28.11	134.29	27.76	138.39	27.72
10.0	122.91	29.78	127.01	28.82	131.11	28.15	135.20	27.78	139.30	27.74
10.1	123.82	29.83	127.92	28.87	132.02	28.19	136.12	27.81	140.21	27.75
10.2	124.73	29.89	128.83	28.92	132.93	28.23	137.03	27.84	141.13	27.78
10.5	127.47	30.06	131.57	29.07	135.67	28.36	139.76	27.95	143.86	27.85
10.8								ORD 9 =	150.70	28.14

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 3 TSCN = Y = 4.990 + 7.576X1 + 11.414X2

X1 = RH2	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	96.10	27.52	107.51	26.73	118.93	26.62	130.34	27.20	141.76	28.42
6.2	97.62	27.37	109.03	26.51	120.44	26.34	131.86	26.86	143.27	28.04
6.4	99.13	27.24	110.54	26.32	121.96	26.08	133.37	26.54	144.79	27.67
6.6	100.65	27.14	112.06	26.15	123.47	25.84	134.89	26.24	146.30	27.32
6.8	102.16	27.06	113.57	26.00	124.99	25.62	136.40	25.96	147.82	26.99
7.0	103.68	27.00	115.09	25.87	126.50	25.43	137.92	25.71	149.33	26.68
7.1	104.43	26.98	115.85	25.82	127.26	25.34	138.68	25.59	150.09	26.53
7.2	105.19	26.97	116.60	25.77	128.02	25.26	139.43	25.47	150.85	26.39
7.3	105.95	26.96	117.36	25.73	128.78	25.18	140.19	25.36	151.60	26.25
7.4	106.71	26.95	118.12	25.69	129.53	25.11	140.95	25.26	152.36	26.12
7.5	107.46	26.96	118.88	25.66	130.29	25.05	141.71	25.16	153.12	26.00
7.6	108.22	26.97	119.64	25.64	131.05	24.99	142.46	25.07	153.88	25.87
7.7	108.98	26.98	120.39	25.62	131.81	24.94	143.22	24.99	154.63	25.76
7.8	109.74	27.00	121.15	25.61	132.56	24.89	143.98	24.91	155.39	25.65
7.9	110.49	27.03	121.91	25.61	133.32	24.85	144.74	24.83	156.15	25.54
8.0	111.25	27.06	122.67	25.61	134.08	24.82	145.49	24.76	156.91	25.45
8.1	112.01	27.10	123.42	25.61	134.84	24.79	146.25	24.70	157.66	25.35
8.2	112.77	27.14	124.18	25.63	135.59	24.77	147.01	24.65	158.42	25.27
8.3	113.52	27.19	124.94	25.65	136.35	24.76	147.77	24.60	159.18	25.19
8.4	114.28	27.25	125.70	25.67	137.11	24.75	148.52	24.56	159.94	25.11
8.5	115.04	27.31	126.45	25.70	137.87	24.75	149.28	24.52	160.70	25.04
8.6	115.80	27.37	127.21	25.74	138.62	24.75	150.04	24.49	161.45	24.98
8.7	116.55	27.45	127.97	25.78	139.38	24.77	150.80	24.47	162.21	24.92
8.8	117.31	27.52	128.73	25.83	140.14	24.78	151.55	24.45	162.97	24.87
8.9	118.07	27.61	129.48	25.89	140.90	24.81	152.31	24.44	163.73	24.83
9.0	118.83	27.70	130.24	25.95	141.66	24.84	153.07	24.44	164.48	24.79
9.1	119.58	27.79	131.00	26.02	142.41	24.87	153.83	24.44	165.24	24.76
9.2	120.34	27.89	131.76	26.09	143.17	24.92	154.58	24.45	166.00	24.73
9.3	121.10	27.99	132.51	26.17	143.93	24.97	155.34	24.47	166.76	24.71
9.4	121.86	28.10	133.27	26.26	144.69	25.02	156.10	24.49	167.51	24.70
9.5	122.62	28.22	134.03	26.35	145.44	25.08	156.86	24.52	168.27	24.69
9.6	123.37	28.34	134.79	26.44	146.20	25.15	157.61	24.55	169.03	24.69
9.7	124.13	28.46	135.54	26.55	146.96	25.22	158.37	24.59	169.79	24.70
9.8	124.89	28.59	136.30	26.65	147.72	25.30	159.13	24.64	170.54	24.71
9.9	125.65	28.73	137.06	26.77	148.47	25.39	159.89	24.69	171.30	24.73
10.0	126.40	28.87	137.82	26.88	149.23	25.48	160.64	24.75	172.06	24.76
10.1	127.16	29.01	138.57	27.01	149.99	25.58	161.40	24.82	172.82	24.79
10.2	127.92	29.16	139.33	27.14	150.75	25.68	162.16	24.89	173.57	24.83
10.3	128.68	29.31	140.09	27.27	151.50	25.79	162.92	24.97	174.33	24.87
10.4	129.43	29.47	140.85	27.41	152.26	25.90	163.67	25.05	175.09	24.92
10.5	130.19	29.63	141.60	27.55	153.02	26.02	164.43	25.14	175.85	24.98
11.0	133.98	30.51	145.39	28.34	156.81	26.70	168.22	25.68	179.63	25.36
11.5								ORD 9 =	194.84	26.11

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 4 TSCN = Y = 23.745 + 13.435X1 + 3.678X2

X1 = RH3	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
4.0	92.20	27.46	95.87	27.23	99.55	27.33	103.23	27.76	106.91	28.49
5.0	105.63	26.96	109.31	26.56	112.99	26.50	116.66	26.78	120.34	27.38
5.5	112.35	26.82	116.03	26.33	119.70	26.19	123.38	26.38	127.06	26.91
6.0	119.07	26.75	122.74	26.18	126.42	25.95	130.10	26.06	133.78	26.51
6.2	121.75	26.74	125.43	26.14	129.11	25.87	132.79	25.95	136.46	26.37
6.3	123.10	26.74	126.77	26.12	130.45	25.84	134.13	25.90	137.81	26.31
6.4	124.44	26.74	128.12	26.11	131.80	25.81	135.47	25.85	139.15	26.24
6.5	125.78	26.75	129.46	26.10	133.14	25.78	136.82	25.81	140.49	26.18
6.6	127.13	26.76	130.81	26.09	134.48	25.75	138.16	25.77	141.84	26.12
6.7	128.47	26.77	132.15	26.09	135.83	25.73	139.50	25.73	143.18	26.07
6.8	129.82	26.79	133.49	26.08	137.17	25.71	140.85	25.69	144.53	26.02
6.9	131.16	26.81	134.84	26.09	138.51	25.70	142.19	25.66	145.87	25.97
7.0	132.50	26.83	136.18	26.09	139.86	25.69	143.53	25.63	147.21	25.92
7.1	133.85	26.85	137.52	26.10	141.20	25.68	144.88	25.60	148.56	25.88
7.2	135.19	26.88	138.87	26.11	142.54	25.67	146.22	25.58	149.90	25.84
7.3	136.53	26.91	140.21	26.12	143.89	25.67	147.57	25.56	151.24	25.80
7.4	137.88	26.94	141.55	26.14	145.23	25.67	148.91	25.54	152.59	25.77
7.5	139.22	26.98	142.90	26.16	146.57	25.67	150.25	25.53	153.93	25.74
7.6	140.56	27.01	144.24	26.18	147.92	25.68	151.60	25.52	155.27	25.71
7.7	141.91	27.06	145.58	26.21	149.26	25.69	152.94	25.51	156.62	25.68
7.8	143.25	27.10	146.93	26.24	150.61	25.70	154.28	25.50	157.96	25.66
7.9	144.59	27.15	148.27	26.27	151.95	25.71	155.63	25.50	159.30	25.64
8.0	145.94	27.20	149.61	26.30	153.29	25.73	156.97	25.50	160.65	25.62
8.1	147.28	27.25	150.96	26.34	154.64	25.75	158.31	25.51	161.99	25.61
8.2	148.62	27.30	152.30	26.38	155.98	25.78	159.66	25.51	163.33	25.60
8.3	149.97	27.36	153.65	26.42	157.32	25.80	161.00	25.52	164.68	25.59
8.4	151.31	27.42	154.99	26.47	158.67	25.83	162.34	25.54	166.02	25.59
8.5	152.66	27.48	156.33	26.52	160.01	25.87	163.69	25.55	167.37	25.59
8.6	154.00	27.55	157.68	26.57	161.35	25.90	165.03	25.57	168.71	25.59
8.7	155.34	27.62	159.02	26.63	162.70	25.94	166.37	25.59	170.05	25.60
8.8	156.69	27.69	160.36	26.68	164.04	25.98	167.72	25.62	171.40	25.60
8.9	158.03	27.76	161.71	26.74	165.38	26.03	169.06	25.65	172.74	25.62
9.0	159.37	27.84	163.05	26.81	166.73	26.08	170.41	25.68	174.08	25.63
9.1	160.72	27.92	164.39	26.87	168.07	26.13	171.75	25.71	175.43	25.65
9.2	162.06	28.00	165.74	26.94	169.41	26.18	173.09	25.75	176.77	25.67
9.3	163.40	28.09	167.08	27.01	170.76	26.24	174.44	25.79	178.11	25.69
9.4	164.75	28.17	168.42	27.09	172.10	26.30	175.78	25.83	179.46	25.72
9.5	166.09	28.26	169.77	27.16	173.45	26.36	177.12	25.88	180.80	25.75
9.6	167.43	28.35	171.11	27.24	174.79	26.42	178.47	25.93	182.14	25.78
9.7	168.78	28.45	172.45	27.32	176.13	26.49	179.81	25.98	183.49	25.81
9.8	170.12	28.55	173.80	27.41	177.48	26.56	181.15	26.04	184.83	25.85
9.9	171.46	28.64	175.14	27.50	178.82	26.64	182.50	26.10	186.17	25.89
10.0	172.81	28.75	176.49	27.58	180.16	26.71	183.84	26.16	'187.52	25.94

'AND ORD 9

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 5 TSCN = Y = -31.916 + 20.748X1 + 1.791X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	99.73	30.34	101.53	29.90	103.32	29.75	105.11	29.88	106.90	30.29
6.2	103.88	30.28	105.68	29.82	107.47	29.65	109.26	29.76	111.05	30.16
6.4	108.03	30.22	109.83	29.75	111.62	29.55	113.41	29.65	115.20	30.03
6.6	112.18	30.18	113.97	29.68	115.77	29.47	117.56	29.55	119.35	29.91
6.8	116.33	30.14	118.12	29.63	119.92	29.40	121.71	29.46	123.50	29.80
7.0	120.48	30.12	122.27	29.58	124.07	29.33	125.86	29.37	127.65	29.70
7.1	122.56	30.11	124.35	29.57	126.14	29.31	127.93	29.34	129.72	29.66
7.2	124.63	30.10	126.42	29.55	128.21	29.28	130.01	29.30	131.80	29.61
7.3	126.71	30.10	128.50	29.54	130.29	29.26	132.08	29.27	133.87	29.57
7.4	128.78	30.09	130.57	29.53	132.36	29.24	134.16	29.24	135.95	29.53
7.5	130.86	30.10	132.65	29.52	134.44	29.22	136.23	29.22	138.02	29.50
7.6	132.93	30.10	134.72	29.51	136.51	29.21	138.31	29.19	140.10	29.47
7.7	135.01	30.11	136.80	29.51	138.59	29.19	140.38	29.17	142.17	29.43
7.8	137.08	30.11	138.87	29.51	140.66	29.19	142.45	29.15	144.25	29.41
7.9	139.16	30.13	140.95	29.51	142.74	29.18	144.53	29.13	146.32	29.38
8.0	141.23	30.14	143.02	29.52	144.81	29.17	146.60	29.12	148.40	29.36
8.1	143.30	30.16	145.10	29.52	146.89	29.17	148.68	29.11	150.47	29.34
8.2	145.38	30.17	147.17	29.53	148.96	29.17	150.75	29.10	152.55	29.32
8.3	147.45	30.20	149.25	29.55	151.04	29.18	152.83	29.09	154.62	29.30
8.4	149.53	30.22	151.32	29.56	153.11	29.18	154.90	29.09	156.69	29.29
8.5	151.60	30.25	153.40	29.58	155.19	29.19	156.98	29.09	158.77	29.28
8.6	153.68	30.27	155.47	29.60	157.26	29.20	159.05	29.09	160.84	29.27
8.7	155.75	30.30	157.54	29.62	159.34	29.21	161.13	29.10	162.92	29.27
8.8	157.83	30.34	159.62	29.65	161.41	29.23	163.20	29.10	164.99	29.27
8.9	159.90	30.37	161.69	29.67	163.49	29.25	165.28	29.11	167.07	29.27
9.0	161.98	30.41	163.77	29.70	165.56	29.27	167.35	29.12	169.14	29.27
9.1	164.05	30.45	165.84	29.74	167.64	29.29	169.43	29.14	171.22	29.27
9.2	166.13	30.50	167.92	29.77	169.71	29.32	171.50	29.15	173.29	29.28
9.3	168.20	30.54	169.99	29.81	171.78	29.35	173.58	29.17	175.37	29.29
9.4	170.28	30.59	172.07	29.85	173.86	29.38	175.65	29.20	177.44	29.30
9.5	172.35	30.64	174.14	29.89	175.93	29.41	177.73	29.22	179.52	29.32
9.6	174.43	30.69	176.22	29.94	178.01	29.45	179.80	29.25	181.59	29.34
9.7	176.50	30.75	178.29	29.98	180.08	29.49	181.88	29.28	183.67	29.36
9.8	178.58	30.81	180.37	30.03	182.16	29.53	183.95	29.31	185.74	29.38
9.9	180.65	30.87	182.44	30.09	184.23	29.58	186.02	29.35	187.82	29.41
10.0	182.73	30.93	184.52	30.14	186.31	29.62	188.10	29.38	189.89	29.44
10.1	184.80	30.99	186.59	30.20	188.38	29.67	190.17	29.42	191.97	29.47
10.2	186.87	31.06	188.67	30.26	190.46	29.72	192.25	29.47	194.04	29.50
10.3	188.95	31.13	190.74	30.32	192.53	29.78	194.32	29.51	196.11	29.54
10.4	191.02	31.20	192.82	30.38	194.61	29.83	196.40	29.56	198.19	29.57
10.5	193.10	31.27	194.89	30.45	196.68	29.89	198.47	29.61	200.26	29.61
11.0	203.47	31.67	205.26	30.82	207.06	30.22	208.85	29.90	210.64	29.86
11.5								ORD 9 =	222.80	30.35

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 6 TSCN = Y = -5.608 + 14.111X1 + 2.172X2

X1 = RH4	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
4.5	66.58	26.73	68.75	25.11	70.92	24.95	73.10	26.28	75.27	28.89
5.0	73.64	26.20	75.81	24.24	77.98	23.77	80.15	24.87	82.32	27.34
5.5	80.69	25.84	82.86	23.54	85.04	22.74	87.21	23.57	89.38	25.89
6.0	87.75	25.66	89.92	23.02	92.09	21.86	94.26	22.40	96.44	24.53
6.5	94.80	25.65	96.97	22.70	99.15	21.17	101.32	21.39	103.49	23.30
6.6	96.21	25.67	98.38	22.66	100.56	21.06	102.73	21.21	104.90	23.06
6.7	97.62	25.70	99.80	22.62	101.97	20.95	104.14	21.03	106.31	22.84
6.8	99.03	25.74	101.21	22.60	103.38	20.86	105.55	20.86	107.72	22.62
6.9	100.45	25.78	102.62	22.58	104.79	20.77	106.96	20.70	109.14	22.41
7.0	101.86	25.83	104.03	22.57	106.20	20.69	108.37	20.55	110.55	22.20
7.1	103.27	25.88	105.44	22.57	107.61	20.61	109.79	20.41	111.96	22.00
7.2	104.68	25.95	106.85	22.58	109.02	20.55	111.20	20.27	113.37	21.80
7.3	106.09	26.02	108.26	22.59	110.43	20.50	112.61	20.14	114.78	21.62
7.4	107.50	26.09	109.67	22.62	111.85	20.45	114.02	20.02	116.19	21.44
7.5	108.91	26.18	111.08	22.65	113.26	20.41	115.43	19.91	117.60	21.26
7.6	110.32	26.27	112.50	22.69	114.67	20.39	116.84	19.81	119.01	21.10
7.7	111.73	26.37	113.91	22.74	116.08	20.37	118.25	19.71	120.42	20.94
7.8	113.15	26.47	115.32	22.79	117.49	20.36	119.66	19.63	121.84	20.79
7.9	114.56	26.58	116.73	22.86	118.90	20.36	121.07	19.55	123.25	20.65
8.0	115.97	26.70	118.14	22.93	120.31	20.37	122.48	19.49	124.66	20.51
8.1	117.38	26.82	119.55	23.01	121.72	20.38	123.90	19.43	126.07	20.39
8.2	118.79	26.95	120.96	23.10	123.13	20.41	125.31	19.38	127.48	20.27
8.3	120.20	27.09	122.37	23.19	124.55	20.45	126.72	19.34	128.89	20.16
8.4	121.61	27.23	123.78	23.29	125.96	20.49	128.13	19.32	130.30	20.06
8.5	123.02	27.38	125.20	23.40	127.37	20.54	129.54	19.30	131.71	19.97
8.6	124.43	27.53	126.61	23.52	128.78	20.61	130.95	19.29	133.12	19.88
8.7	125.85	27.69	128.02	23.65	130.19	20.68	132.36	19.29	134.53	19.81
8.8	127.26	27.86	129.43	23.78	131.60	20.76	133.77	19.30	135.95	19.74
8.9	128.67	28.03	130.84	23.92	133.01	20.85	135.18	19.31	137.36	19.69
9.0	130.08	28.20	132.25	24.06	134.42	20.94	136.60	19.34	138.77	19.64
9.1	131.49	28.39	133.66	24.22	135.83	21.05	138.01	19.38	140.18	19.60
9.2	132.90	28.57	135.07	24.37	137.25	21.16	139.42	19.43	141.59	19.57
9.3	134.31	28.77	136.48	24.54	138.66	21.28	140.83	19.49	143.00	19.56
9.4	135.72	28.96	137.90	24.71	140.07	21.41	142.24	19.55	144.41	19.55
9.5	137.13	29.17	139.31	24.89	141.48	21.55	143.65	19.63	145.82	19.55
9.6	138.54	29.37	140.72	25.07	142.89	21.69	145.06	19.71	147.23	19.56
9.7	139.96	29.59	142.13	25.26	144.30	21.85	146.47	19.80	148.65	19.58
9.8	141.37	29.80	143.54	25.46	145.71	22.01	147.88	19.91	150.06	19.60
9.9	142.78	30.03	144.95	25.66	147.12	22.17	149.30	20.02	151.47	19.64
10.0	144.19	30.25	146.36	25.87	148.53	22.35	150.71	20.14	152.88	19.69
10.1	145.60	30.48	147.77	26.08	149.95	22.53	152.12	20.27	154.29	19.75
10.2	147.01	30.72	149.18	26.30	151.36	22.72	153.53	20.40	155.70	19.81
10.5	151.24	31.45	153.42	26.99	155.59	23.32	157.76	20.86	159.93	20.06
10.8								ORD 9 =	166.34	21.22

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 7 TSCN = Y = -24.545 + 12.056X1 + 6.761X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	74.83	31.21	81.60	29.97	88.36	29.29	95.12	29.19	101.88	29.69
6.2	77.25	31.09	84.01	29.82	90.77	29.10	97.53	28.97	104.29	29.44
6.4	79.66	30.98	86.42	29.67	93.18	28.92	99.94	28.76	106.70	29.21
6.6	82.07	30.89	88.83	29.54	95.59	28.76	102.35	28.56	109.11	28.98
6.8	84.48	30.81	91.24	29.43	98.00	28.60	104.76	28.38	111.52	28.77
7.0	86.89	30.74	93.65	29.33	100.41	28.47	107.17	28.21	113.93	28.57
7.1	88.10	30.71	94.86	29.28	101.62	28.41	108.38	28.13	115.14	28.47
7.2	89.30	30.69	96.06	29.24	102.82	28.35	109.58	28.05	116.34	28.38
7.3	90.51	30.66	97.27	29.20	104.03	28.29	110.79	27.98	117.55	28.29
7.4	91.71	30.65	98.47	29.17	105.23	28.24	111.99	27.91	118.76	28.21
7.5	92.92	30.63	99.68	29.14	106.44	28.19	113.20	27.85	119.96	28.13
7.6	94.12	30.62	100.89	29.11	107.65	28.15	114.41	27.79	121.17	28.05
7.7	95.33	30.61	102.09	29.09	108.85	28.10	115.61	27.73	122.37	27.98
7.8	96.54	30.61	103.30	29.06	110.06	28.07	116.82	27.67	123.58	27.91
7.9	97.74	30.61	104.50	29.05	111.26	28.03	118.02	27.62	124.78	27.84
8.0	98.95	30.61	105.71	29.03	112.47	28.00	119.23	27.57	125.99	27.78
8.1	100.15	30.61	106.91	29.02	113.67	27.98	120.43	27.53	127.19	27.72
8.2	101.36	30.62	108.12	29.02	114.88	27.95	121.64	27.49	128.40	27.66
8.3	102.56	30.64	109.32	29.02	116.08	27.93	122.85	27.45	129.61	27.61
8.4	103.77	30.65	110.53	29.02	117.29	27.92	124.05	27.42	130.81	27.56
8.5	104.97	30.67	111.74	29.02	118.50	27.91	125.26	27.39	132.02	27.51
8.6	106.18	30.69	112.94	29.03	119.70	27.90	126.46	27.37	133.22	27.47
8.7	107.39	30.72	114.15	29.04	120.91	27.89	127.67	27.35	134.43	27.44
8.8	108.59	30.75	115.35	29.06	122.11	27.89	128.87	27.33	135.63	27.40
8.9	109.80	30.78	116.56	29.08	123.32	27.90	130.08	27.32	136.84	27.37
9.0	111.00	30.82	117.76	29.10	124.52	27.90	131.28	27.31	138.05	27.34
9.1	112.21	30.86	118.97	29.12	125.73	27.92	132.49	27.30	139.25	27.32
9.2	113.41	30.90	120.17	29.15	126.94	27.93	133.70	27.30	140.46	27.30
9.3	114.62	30.95	121.38	29.19	128.14	27.95	134.90	27.30	141.66	27.29
9.4	115.83	31.00	122.59	29.22	129.35	27.97	136.11	27.31	142.87	27.28
9.5	117.03	31.05	123.79	29.26	130.55	28.00	137.31	27.32	144.07	27.27
9.6	118.24	31.10	125.00	29.31	131.76	28.03	138.52	27.33	145.28	27.27
9.7	119.44	31.16	126.20	29.35	132.96	28.06	139.72	27.35	146.48	27.27
9.8	120.65	31.23	127.41	29.41	134.17	28.10	140.93	27.37	147.69	27.27
9.9	121.85	31.29	128.61	29.46	135.37	28.14	142.14	27.39	148.90	27.28
10.0	123.06	31.36	129.82	29.52	136.58	28.18	143.34	27.42	150.10	27.29
10.1	124.26	31.43	131.03	29.58	137.79	28.23	144.55	27.45	151.31	27.31
10.2	125.47	31.51	132.23	29.64	138.99	28.28	145.75	27.49	152.51	27.33
10.3	126.68	31.59	133.44	29.71	140.20	28.33	146.96	27.53	153.72	27.35
10.4	127.88	31.67	134.64	29.78	141.40	28.39	148.16	27.57	154.92	27.38
10.5	129.09	31.75	135.85	29.86	142.61	28.45	149.37	27.62	156.13	27.41
11.0	135.12	32.22	141.88	30.28	148.64	28.82	155.40	27.91	162.16	27.62
11.5								ORD 9 =	174.95	28.17

CONTINUED . . .

1966 TREE 8 TSCN = Y = -22.435 + 9.797X1 + 4.969X2

X1 = RH3	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
4.0	36.63	33.88	41.60	32.05	46.57	31.41	51.54	32.02	56.51	33.82
5.0	46.43	31.62	51.40	29.22	56.37	28.06	61.33	28.30	66.30	29.90
5.5	51.33	30.76	56.29	28.06	61.26	26.62	66.23	26.63	71.20	28.10
6.0	56.22	30.11	61.19	27.11	66.16	25.37	71.13	25.13	76.10	26.45
6.2	58.18	29.91	63.15	26.80	68.12	24.93	73.09	24.58	78.06	25.83
6.3	59.16	29.82	64.13	26.65	69.10	24.72	74.07	24.32	79.04	25.53
6.4	60.14	29.75	65.11	26.52	70.08	24.53	75.05	24.07	80.02	25.24
6.5	61.12	29.68	66.09	26.40	71.06	24.34	76.03	23.83	81.00	24.96
6.6	62.10	29.62	67.07	26.28	72.04	24.16	77.01	23.59	81.98	24.69
6.7	63.08	29.57	68.05	26.18	73.02	24.00	77.99	23.37	82.96	24.42
6.8	64.06	29.53	69.03	26.08	74.00	23.84	78.97	23.16	83.94	24.16
6.9	65.04	29.50	70.01	26.00	74.98	23.70	79.95	22.95	84.92	23.91
7.0	66.02	29.48	70.99	25.93	75.96	23.56	80.93	22.76	85.90	23.67
7.1	67.00	29.47	71.97	25.86	76.94	23.44	81.91	22.57	86.88	23.44
7.2	67.98	29.46	72.95	25.81	77.92	23.33	82.89	22.40	87.86	23.22
7.3	68.96	29.47	73.93	25.77	78.90	23.23	83.87	22.24	88.84	23.01
7.4	69.94	29.48	74.91	25.74	79.88	23.14	84.85	22.09	89.82	22.81
7.5	70.92	29.51	75.89	25.72	80.86	23.06	85.83	21.95	90.80	22.62
7.6	71.90	29.54	76.87	25.71	81.84	22.99	86.81	21.82	91.78	22.44
7.7	72.88	29.59	77.85	25.71	82.82	22.94	87.79	21.71	92.76	22.27
7.8	73.86	29.64	78.83	25.72	83.80	22.90	88.77	21.61	93.74	22.11
7.9	74.84	29.70	79.81	25.74	84.78	22.87	89.75	21.52	94.72	21.97
8.0	75.82	29.78	80.79	25.78	85.76	22.85	90.73	21.44	95.70	21.84
8.1	76.80	29.86	81.77	25.82	86.74	22.84	91.71	21.37	96.67	21.71
8.2	77.78	29.95	82.75	25.88	87.72	22.85	92.69	21.32	97.65	21.60
8.3	78.76	30.05	83.73	25.94	88.70	22.87	93.66	21.28	98.63	21.51
8.4	79.74	30.15	84.71	26.02	89.68	22.90	94.64	21.25	99.61	21.42
8.5	80.72	30.27	85.69	26.10	90.65	22.94	95.62	21.24	100.59	21.35
8.6	81.70	30.39	86.67	26.20	91.63	23.00	96.60	21.24	101.57	21.29
8.7	82.68	30.53	87.65	26.31	92.61	23.07	97.58	21.25	102.55	21.24
8.8	83.66	30.67	88.62	26.42	93.59	23.14	98.56	21.28	103.53	21.21
8.9	84.64	30.82	89.60	26.55	94.57	23.23	99.54	21.32	104.51	21.19
9.0	85.61	30.98	90.58	26.69	95.55	23.34	100.52	21.37	105.49	21.18
9.1	86.59	31.15	91.56	26.83	96.53	23.45	101.50	21.43	106.47	21.18
9.2	87.57	31.32	92.54	26.99	97.51	23.57	102.48	21.51	107.45	21.20
9.3	88.55	31.50	93.52	27.15	98.49	23.71	103.46	21.60	108.43	21.23
9.4	89.53	31.69	94.50	27.33	99.47	23.85	104.44	21.70	109.41	21.28
9.5	90.51	31.89	95.48	27.51	100.45	24.01	105.42	21.82	110.39	21.33
9.6	91.49	32.10	96.46	27.70	101.43	24.18	106.40	21.94	111.37	21.40
9.7	92.47	32.31	97.44	27.90	102.41	24.36	107.38	22.08	112.35	21.49
9.8	93.45	32.53	98.42	28.11	103.39	24.54	108.36	22.23	113.33	21.58
9.9	94.43	32.75	99.40	28.33	104.37	24.74	109.34	22.39	114.31	21.69
10.0	95.41	32.99	100.38	28.55	105.35	24.95	110.32	22.56	'115.29	21.81

'AND ORD 9

CONTINUED . . .

APPENDIX 9 CONTINUED

1966	TREE 9	TSCN = Y = -72.626 + 15.514X1 + 8.756X2								
X1 = RH2	X2 = ORD									
	4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	55.48	33.75	64.24	31.41	72.99	30.15	81.75	30.09	90.51	31.26
6.2	58.58	33.23	67.34	30.81	76.10	29.47	84.85	29.36	93.61	30.50
6.4	61.69	32.75	70.44	30.24	79.20	28.82	87.96	28.66	96.71	29.78
6.6	64.79	32.31	73.55	29.71	82.30	28.21	91.06	27.99	99.81	29.09
6.8	67.89	31.91	76.65	29.22	85.40	27.64	94.16	27.36	102.92	28.43
7.0	70.99	31.54	79.75	28.77	88.51	27.11	97.26	26.77	106.02	27.80
7.1	72.55	31.37	81.30	28.56	90.06	26.85	98.81	26.49	107.57	27.50
7.2	74.10	31.22	82.85	28.36	91.61	26.62	100.37	26.21	109.12	27.21
7.3	75.65	31.07	84.40	28.17	93.16	26.39	101.92	25.95	110.67	26.94
7.4	77.20	30.93	85.96	27.99	94.71	26.17	103.47	25.70	112.23	26.67
7.5	78.75	30.81	87.51	27.83	96.26	25.96	105.02	25.47	113.78	26.41
7.6	80.30	30.70	89.06	27.67	97.82	25.77	106.57	25.24	115.33	26.16
7.7	81.85	30.59	90.61	27.53	99.37	25.59	108.12	25.02	116.88	25.93
7.8	83.41	30.50	92.16	27.40	100.92	25.42	109.67	24.82	118.43	25.70
7.9	84.96	30.42	93.71	27.29	102.47	25.27	111.23	24.63	119.98	25.49
8.0	86.51	30.35	95.26	27.18	104.02	25.12	112.78	24.46	121.53	25.29
8.1	88.06	30.29	96.82	27.09	105.57	25.00	114.33	24.29	123.08	25.10
8.2	89.61	30.25	98.37	27.01	107.12	24.88	115.88	24.14	124.64	24.93
8.3	91.16	30.22	99.92	26.95	108.67	24.78	117.43	24.01	126.19	24.77
8.4	92.71	30.19	101.47	26.89	110.23	24.69	118.98	23.89	127.74	24.62
8.5	94.26	30.18	103.02	26.85	111.78	24.62	120.53	23.78	129.29	24.48
8.6	95.82	30.18	104.57	26.83	113.33	24.56	122.09	23.68	130.84	24.36
8.7	97.37	30.20	106.12	26.81	114.88	24.51	123.64	23.61	132.39	24.25
8.8	98.92	30.22	107.68	26.81	116.43	24.48	125.19	23.54	133.94	24.16
8.9	100.47	30.26	109.23	26.83	117.98	24.46	126.74	23.49	135.50	24.08
9.0	102.02	30.30	110.78	26.85	119.53	24.46	128.29	23.46	137.05	24.02
9.1	103.57	30.36	112.33	26.89	121.09	24.47	129.84	23.44	138.60	23.97
9.2	105.12	30.43	113.88	26.94	122.64	24.50	131.39	23.43	140.15	23.93
9.3	106.68	30.51	115.43	27.01	124.19	24.54	132.94	23.44	141.70	23.91
9.4	108.23	30.61	116.98	27.08	125.74	24.60	134.50	23.47	143.25	23.90
9.5	109.78	30.71	118.53	27.17	127.29	24.66	136.05	23.51	144.80	23.91
9.6	111.33	30.83	120.09	27.28	128.84	24.75	137.60	23.57	146.36	23.94
9.7	112.88	30.95	121.64	27.39	130.39	24.84	139.15	23.64	147.91	23.98
9.8	114.43	31.09	123.19	27.52	131.95	24.96	140.70	23.72	149.46	24.03
9.9	115.98	31.24	124.74	27.66	133.50	25.08	142.25	23.82	151.01	24.10
10.0	117.54	31.40	126.29	27.81	135.05	25.22	143.80	23.94	152.56	24.18
10.1	119.09	31.57	127.84	27.98	136.60	25.37	145.36	24.06	154.11	24.27
10.2	120.64	31.75	129.39	28.15	138.15	25.53	146.91	24.21	155.66	24.38
10.3	122.19	31.93	130.95	28.34	139.70	25.71	148.46	24.36	157.21	24.51
10.4	123.74	32.13	132.50	28.54	141.25	25.90	150.01	24.53	158.77	24.65
10.5	125.29	32.34	134.05	28.75	142.80	26.10	151.56	24.71	160.32	24.80
11.0	133.05	33.52	141.81	29.95	150.56	27.28	159.32	25.81	168.07	25.75
11.5								ORD 9 =	184.59	28.15

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 10 TSCN = Y = −29.926 + 11.455X1 + 8.199X2

X1 = RH1	X2 = ORD 4 Y	4 +−	5 Y	5 +−	6 Y	6 +−	7 Y	7 +−	8 Y	8 +−
5.0	60.14	35.90	68.34	33.83	76.54	32.98	84.74	33.42	92.94	35.12
5.5	65.87	34.50	74.07	32.17	82.27	31.07	90.47	31.35	98.67	32.98
6.0	71.60	33.41	79.80	30.80	88.00	29.45	96.20	29.55	104.39	31.07
6.5	77.33	32.66	85.53	29.78	93.72	28.17	101.92	28.06	110.12	29.45
7.0	83.05	32.26	91.25	29.13	99.45	27.27	107.65	26.93	115.85	28.17
7.5	88.78	32.22	96.98	28.89	105.18	26.78	113.38	26.21	121.58	27.27
8.0	94.51	32.56	102.71	29.06	110.91	26.75	119.11	25.94	127.30	26.78
8.5	100.24	33.26	108.44	29.64	116.63	27.15	124.83	26.13	133.03	26.75
9.0	105.96	34.30	114.16	30.60	122.36	27.99	130.56	26.78	138.76	27.15
9.5	111.69	35.64	119.89	31.91	128.09	29.21	136.29	27.84	144.49	27.99
10.0	117.42	37.26	125.62	33.53	133.82	30.78	142.02	29.27	150.21	29.21
10.5								ORD 9 =	164.14	31.91

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 11 TSCN = Y = -13.995 + 6.861X1 + 10.366X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	68.64	21.68	79.00	20.92	89.37	21.11	99.73	22.23	110.10	24.15
6.2	70.01	21.48	80.37	20.60	90.74	20.70	101.11	21.74	111.47	23.61
6.4	71.38	21.30	81.75	20.32	92.11	20.31	102.48	21.27	112.84	23.09
6.6	72.75	21.16	83.12	20.06	93.48	19.94	103.85	20.82	114.22	22.58
6.8	74.12	21.05	84.49	19.83	94.86	19.61	105.22	20.39	115.59	22.09
7.0	75.50	20.96	85.86	19.64	96.23	19.30	106.59	19.99	116.96	21.62
7.1	76.18	20.93	86.55	19.55	96.91	19.15	107.28	19.80	117.65	21.39
7.2	76.87	20.91	87.23	19.47	97.60	19.02	107.97	19.61	118.33	21.17
7.3	77.55	20.90	87.92	19.40	98.29	18.89	108.65	19.43	119.02	20.96
7.4	78.24	20.89	88.61	19.34	98.97	18.77	109.34	19.26	119.70	20.74
7.5	78.93	20.89	89.29	19.28	99.66	18.65	110.02	19.09	120.39	20.54
7.6	79.61	20.90	89.98	19.24	100.35	18.55	110.71	18.93	121.08	20.34
7.7	80.30	20.91	90.67	19.20	101.03	18.45	111.40	18.78	121.76	20.14
7.8	80.99	20.94	91.35	19.17	101.72	18.36	112.08	18.64	122.45	19.96
7.9	81.67	20.97	92.04	19.15	102.40	18.28	112.77	18.50	123.14	19.78
8.0	82.36	21.01	92.72	19.14	103.09	18.21	113.46	18.38	123.82	19.60
8.1	83.04	21.06	93.41	19.13	103.78	18.15	114.14	18.25	124.51	19.43
8.2	83.73	21.11	94.10	19.14	104.46	18.09	114.83	18.14	125.19	19.27
8.3	84.42	21.17	94.78	19.15	105.15	18.05	115.51	18.04	125.88	19.12
8.4	85.10	21.24	95.47	19.17	105.83	18.01	116.20	17.94	126.57	18.97
8.5	85.79	21.32	96.15	19.20	106.52	17.99	116.89	17.86	127.25	18.84
8.6	86.47	21.41	96.84	19.24	107.21	17.97	117.57	17.78	127.94	18.71
8.7	87.16	21.50	97.53	19.29	107.89	17.96	118.26	17.71	128.62	18.58
8.8	87.85	21.60	98.21	19.34	108.58	17.96	118.94	17.65	129.31	18.47
8.9	88.53	21.70	98.90	19.41	109.26	17.97	119.63	17.60	130.00	18.36
9.0	89.22	21.82	99.58	19.48	109.95	17.99	120.32	17.56	130.68	18.26
9.1	89.90	21.94	100.27	19.56	110.64	18.02	121.00	17.52	131.37	18.17
9.2	90.59	22.06	100.96	19.65	111.32	18.05	121.69	17.50	132.05	18.09
9.3	91.28	22.20	101.64	19.74	112.01	18.10	122.37	17.49	132.74	18.02
9.4	91.96	22.34	102.33	19.85	112.70	18.15	123.06	17.48	133.43	17.95
9.5	92.65	22.48	103.02	19.96	113.38	18.21	123.75	17.49	134.11	17.90
9.6	93.34	22.64	103.70	20.08	114.07	18.29	124.43	17.50	134.80	17.85
9.7	94.02	22.79	104.39	20.20	114.75	18.37	125.12	17.52	135.49	17.82
9.8	94.71	22.96	105.07	20.34	115.44	18.46	125.81	17.56	136.17	17.79
9.9	95.39	23.13	105.76	20.48	116.13	18.55	126.49	17.60	136.86	17.77
10.0	96.08	23.31	106.45	20.62	116.81	18.66	127.18	17.65	137.54	17.76
10.1	96.77	23.49	107.13	20.78	117.50	18.77	127.86	17.71	138.23	17.76
10.2	97.45	23.67	107.82	20.94	118.18	18.89	128.55	17.78	138.92	17.77
10.3	98.14	23.87	108.50	21.11	118.87	19.02	129.24	17.85	139.60	17.79
10.4	98.82	24.07	109.19	21.28	119.56	19.16	129.92	17.94	140.29	17.81
10.5	99.51	24.27	109.88	21.46	120.24	19.30	130.61	18.04	140.97	17.85
11.0	102.94	25.36	113.31	22.44	123.67	20.13	134.04	18.63	144.40	18.16
11.5								ORD 9 =	158.20	19.02

CONTINUED . . .

APPENDIX 9 CONTINUED

1966 TREE 12 TSCN = Y = 8.009 + 9.353X1 + 4.315X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	81.38	28.66	85.70	28.04	90.01	27.75	94.33	27.79	98.64	28.17
6.2	83.25	28.64	87.57	28.00	91.88	27.69	96.20	27.71	100.51	28.07
6.4	85.12	28.63	89.44	27.97	93.75	27.63	98.07	27.64	102.38	27.97
6.6	87.00	28.62	91.31	27.94	95.62	27.59	99.94	27.57	104.25	27.88
6.8	88.87	28.62	93.18	27.92	97.50	27.54	101.81	27.50	106.13	27.80
7.0	90.74	28.63	95.05	27.91	99.37	27.51	103.68	27.44	108.00	27.72
7.1	91.67	28.63	95.99	27.90	100.30	27.49	104.62	27.42	108.93	27.69
7.2	92.61	28.64	96.92	27.90	101.24	27.48	105.55	27.39	109.87	27.65
7.3	93.54	28.65	97.86	27.90	102.17	27.46	106.49	27.37	110.80	27.62
7.4	94.48	28.66	98.79	27.90	103.11	27.45	107.42	27.35	111.74	27.59
7.5	95.41	28.67	99.73	27.90	104.04	27.44	108.36	27.33	112.67	27.56
7.6	96.35	28.68	100.66	27.90	104.98	27.44	109.29	27.31	113.61	27.53
7.7	97.28	28.70	101.60	27.90	105.91	27.43	110.23	27.29	114.54	27.50
7.8	98.22	28.71	102.53	27.91	106.85	27.43	111.16	27.28	115.48	27.47
7.9	99.15	28.73	103.47	27.92	107.78	27.42	112.10	27.27	116.41	27.45
8.0	100.09	28.75	104.40	27.93	108.72	27.42	113.03	27.25	117.35	27.43
8.1	101.02	28.77	105.34	27.94	109.65	27.42	113.97	27.24	118.28	27.41
8.2	101.96	28.79	106.27	27.95	110.59	27.42	114.90	27.23	119.22	27.39
8.3	102.89	28.82	107.21	27.96	111.52	27.43	115.84	27.23	120.15	27.37
8.4	103.83	28.84	108.14	27.98	112.46	27.43	116.77	27.22	121.09	27.35
8.5	104.77	28.87	109.08	28.00	113.39	27.44	117.71	27.22	122.02	27.34
8.6	105.70	28.90	110.02	28.01	114.33	27.45	118.64	27.22	122.96	27.33
8.7	106.64	28.92	110.95	28.03	115.27	27.46	119.58	27.21	123.89	27.31
8.8	107.57	28.96	111.89	28.06	116.20	27.47	120.52	27.22	124.83	27.31
8.9	108.51	28.99	112.82	28.08	117.14	27.48	121.45	27.22	125.77	27.30
9.0	109.44	29.02	113.76	28.10	118.07	27.50	122.39	27.22	126.70	27.29
9.1	110.38	29.06	114.69	28.13	119.01	27.51	123.32	27.23	127.64	27.29
9.2	111.31	29.09	115.63	28.16	119.94	27.53	124.26	27.24	128.57	27.28
9.3	112.25	29.13	116.56	28.19	120.88	27.55	125.19	27.24	129.51	27.28
9.4	113.18	29.17	117.50	28.22	121.81	27.57	126.13	27.26	130.44	27.28
9.5	114.12	29.21	118.43	28.25	122.75	27.59	127.06	27.27	131.38	27.28
9.6	115.05	29.26	119.37	28.28	123.68	27.62	128.00	27.28	132.31	27.29
9.7	115.99	29.30	120.30	28.32	124.62	27.64	128.93	27.30	133.25	27.29
9.8	116.92	29.35	121.24	28.36	125.55	27.67	129.87	27.31	134.18	27.30
9.9	117.86	29.39	122.17	28.39	126.49	27.70	130.80	27.33	135.12	27.30
10.0	118.79	29.44	123.11	28.43	127.42	27.73	131.74	27.35	136.05	27.31
10.1	119.73	29.49	124.04	28.48	128.36	27.76	132.67	27.37	136.99	27.33
10.2	120.66	29.54	124.98	28.52	129.29	27.80	133.61	27.40	137.92	27.34
10.3	121.60	29.60	125.91	28.56	130.23	27.83	134.54	27.42	138.86	27.35
10.4	122.54	29.65	126.85	28.61	131.16	27.87	135.48	27.45	139.79	27.37
10.5	123.47	29.70	127.79	28.66	132.10	27.91	136.41	27.48	140.73	27.39
11.0	128.15	30.00	132.46	28.91	136.78	28.12	141.09	27.64	145.41	27.50
11.5								ORD 9 =	154.40	27.79

CONTINUED . . .

APPENDIX 9 CONTINUED

1968 TREE 1 TSCN = Y = 35.011 + 3.298X1 + 14.361X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	112.24	47.17	126.60	45.49	140.96	45.29	155.33	46.61	169.69	49.32
6.2	112.90	46.66	127.26	44.83	141.62	44.50	155.98	45.72	170.35	48.36
6.4	113.56	46.20	127.92	44.22	142.28	43.76	156.64	44.87	171.01	47.44
6.6	114.22	45.80	128.58	43.67	142.94	43.08	157.30	44.07	171.67	46.56
6.8	114.88	45.46	129.24	43.18	143.60	42.44	157.96	43.32	172.32	45.73
7.0	115.54	45.18	129.90	42.76	144.26	41.87	158.62	42.63	172.98	44.94
7.1	115.87	45.07	130.23	42.56	144.59	41.61	158.95	42.30	173.31	44.57
7.2	116.20	44.96	130.56	42.39	144.92	41.36	159.28	41.99	173.64	44.21
7.3	116.53	44.88	130.89	42.23	145.25	41.13	159.61	41.69	173.97	43.86
7.4	116.86	44.81	131.22	42.09	145.58	40.91	159.94	41.41	174.30	43.53
7.5	117.19	44.75	131.55	41.96	145.91	40.71	160.27	41.14	174.63	43.21
7.6	117.52	44.71	131.88	41.85	146.24	40.53	160.60	40.89	174.96	42.90
7.7	117.85	44.69	132.21	41.76	146.57	40.36	160.93	40.66	175.29	42.61
7.8	118.18	44.68	132.54	41.68	146.90	40.21	161.26	40.44	175.62	42.33
7.9	118.51	44.69	132.87	41.62	147.23	40.08	161.59	40.24	175.95	42.07
8.0	118.84	44.72	133.20	41.58	147.56	39.96	161.92	40.05	176.28	41.83
8.1	119.17	44.76	133.53	41.56	147.89	39.87	162.25	39.88	176.61	41.60
8.2	119.50	44.81	133.86	41.55	148.22	39.79	162.58	39.73	176.94	41.38
8.3	119.83	44.89	134.19	41.56	148.55	39.72	162.91	39.59	177.27	41.18
8.4	120.16	44.97	134.52	41.58	148.88	39.68	163.24	39.48	177.60	41.00
8.5	120.49	45.08	134.85	41.63	149.21	39.65	163.57	39.38	177.93	40.83
8.6	120.82	45.20	135.18	41.69	149.54	39.64	163.90	39.29	178.26	40.69
8.7	121.15	45.33	135.51	41.76	149.87	39.65	164.23	39.23	178.59	40.55
8.8	121.48	45.48	135.84	41.86	150.20	39.68	164.56	39.19	178.92	40.44
8.9	121.81	45.64	136.17	41.97	150.53	39.72	164.89	39.16	179.25	40.34
9.0	122.14	45.82	136.50	42.10	150.86	39.79	165.22	39.15	179.58	40.26
9.1	122.47	46.02	136.83	42.24	151.19	39.87	165.55	39.16	179.91	40.20
9.2	122.80	46.23	137.16	42.40	151.52	39.96	165.88	39.18	180.24	40.15
9.3	123.13	46.45	137.49	42.57	151.85	40.08	166.21	39.23	180.57	40.13
9.4	123.46	46.69	137.82	42.77	152.18	40.21	166.54	39.29	180.90	40.12
9.5	123.79	46.94	138.15	42.97	152.51	40.36	166.87	39.37	181.23	40.12
9.6	124.12	47.20	138.48	43.20	152.84	40.53	167.20	39.47	181.56	40.15
9.7	124.45	47.48	138.81	43.43	153.17	40.71	167.53	39.59	181.89	40.19
9.8	124.78	47.77	139.14	43.69	153.50	40.91	167.86	39.72	182.22	40.25
9.9	125.10	48.08	139.47	43.96	153.83	41.13	168.19	39.87	182.55	40.33
10.0	125.43	48.39	139.80	44.24	154.16	41.36	168.52	40.04	182.88	40.43
10.1	125.76	48.72	140.13	44.53	154.49	41.61	168.85	40.22	183.21	40.54
10.2	126.09	49.06	140.46	44.84	154.82	41.87	169.18	40.43	183.54	40.67
10.3	126.42	49.42	140.78	45.17	155.15	42.15	169.51	40.65	183.87	40.82
10.4	126.75	49.78	141.11	45.50	155.48	42.44	169.84	40.88	184.20	40.98
10.5	127.08	50.16	141.44	45.85	155.81	42.75	170.17	41.13	184.53	41.16
11.0	128.73	52.21	143.09	47.79	157.45	44.50	171.82	42.61	186.18	42.31
11.5								ORD 9 =	202.19	44.78

CONTINUED . . .

APPENDIX 9 CONTINUED

1968 TREE 2 TSCN = Y = 6.469 + 8.588X1 + 5.537X2

X1 = RH4	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
4.5	67.26	23.92	72.80	23.93	78.34	24.20	83.88	24.72	89.41	25.48
5.0	71.56	23.58	77.10	23.50	82.63	23.70	88.17	24.15	93.71	24.85
5.5	75.85	23.31	81.39	23.15	86.93	23.26	92.46	23.65	98.00	24.28
6.0	80.15	23.12	85.68	22.88	91.22	22.91	96.76	23.21	102.30	23.78
6.5	84.44	23.01	89.98	22.68	95.52	22.63	101.05	22.86	106.59	23.35
6.6	85.30	23.00	90.84	22.66	96.37	22.59	101.91	22.79	107.45	23.27
6.7	86.16	22.99	91.70	22.63	97.23	22.54	102.77	22.74	108.31	23.20
6.8	87.02	22.99	92.55	22.61	98.09	22.51	103.63	22.68	109.17	23.13
6.9	87.88	22.99	93.41	22.59	98.95	22.47	104.49	22.63	110.02	23.06
7.0	88.74	22.99	94.27	22.58	99.81	22.44	105.35	22.58	110.88	22.99
7.1	89.59	22.99	95.13	22.56	100.67	22.41	106.21	22.53	111.74	22.93
7.2	90.45	23.00	95.99	22.56	101.53	22.38	107.06	22.49	112.60	22.87
7.3	91.31	23.02	96.85	22.55	102.39	22.36	107.92	22.45	113.46	22.82
7.4	92.17	23.03	97.71	22.55	103.25	22.34	108.78	22.42	114.32	22.77
7.5	93.03	23.05	98.57	22.55	104.10	22.33	109.64	22.38	115.18	22.72
7.6	93.89	23.07	99.43	22.56	104.96	22.32	110.50	22.35	116.04	22.67
7.7	94.75	23.10	100.28	22.57	105.82	22.31	111.36	22.33	116.90	22.63
7.8	95.61	23.13	101.14	22.58	106.68	22.30	112.22	22.31	117.75	22.59
7.9	96.47	23.16	102.00	22.59	107.54	22.30	113.08	22.29	118.61	22.56
8.0	97.32	23.19	102.86	22.61	108.40	22.30	113.94	22.27	119.47	22.53
8.1	98.18	23.23	103.72	22.64	109.26	22.31	114.79	22.26	120.33	22.50
8.2	99.04	23.27	104.58	22.66	110.12	22.32	115.65	22.25	121.19	22.47
8.3	99.90	23.32	105.44	22.69	110.97	22.33	116.51	22.25	122.05	22.45
8.4	100.76	23.36	106.30	22.72	111.83	22.35	117.37	22.25	122.91	22.43
8.5	101.62	23.42	107.16	22.76	112.69	22.36	118.23	22.25	123.77	22.42
8.6	102.48	23.47	108.01	22.80	113.55	22.39	119.09	22.25	124.63	22.40
8.7	103.34	23.53	108.87	22.84	114.41	22.41	119.95	22.26	125.48	22.40
8.8	104.19	23.59	109.73	22.89	115.27	22.44	120.81	22.28	126.34	22.39
8.9	105.05	23.65	110.59	22.93	116.13	22.48	121.66	22.29	127.20	22.39
9.0	105.91	23.72	111.45	22.99	116.99	22.51	122.52	22.31	128.06	22.39
9.1	106.77	23.79	112.31	23.04	117.85	22.55	123.38	22.33	128.92	22.40
9.2	107.63	23.86	113.17	23.10	118.70	22.59	124.24	22.36	129.78	22.40
9.3	108.49	23.94	114.03	23.16	119.56	22.64	125.10	22.39	130.64	22.42
9.4	109.35	24.02	114.88	23.23	120.42	22.69	125.96	22.42	131.50	22.43
9.5	110.21	24.10	115.74	23.29	121.28	22.74	126.82	22.46	132.35	22.45
9.6	111.07	24.18	116.60	23.37	122.14	22.80	127.68	22.50	133.21	22.47
9.7	111.92	24.27	117.46	23.44	123.00	22.86	128.54	22.54	134.07	22.50
9.8	112.78	24.36	118.32	23.52	123.86	22.92	129.39	22.59	134.93	22.53
9.9	113.64	24.45	119.18	23.60	124.72	22.98	130.25	22.64	135.79	22.56
10.0	114.50	24.55	120.04	23.68	125.57	23.05	131.11	22.69	136.65	22.60
10.1	115.36	24.65	120.90	23.77	126.43	23.13	131.97	22.74	137.51	22.64
10.2	116.22	24.75	121.76	23.86	127.29	23.20	132.83	22.80	138.37	22.68
10.5	118.80	25.07	124.33	24.14	129.87	23.44	135.41	23.00	140.94	22.83
10.8								ORD 9 =	149.06	23.05

CONTINUED . . .

1968 TREE 4 TSCN = Y = 20.537 + 15.572X1

VARIABLE ORD NEGATIVE AND
NON-SIGNIFICANT, THEREFORE
EXCLUDED FROM EQUATION

X1 = RH3	Y	+-
4.0	82.82	32.27
5.0	98.40	29.51
5.5	106.18	28.29
6.0	113.97	27.21
6.2	117.08	26.81
6.3	118.64	26.63
6.4	120.20	26.45
6.5	121.75	26.27
6.6	123.31	26.10
6.7	124.87	25.94
6.8	126.43	25.79
6.9	127.98	25.64
7.0	129.54	25.50
7.1	131.10	25.36
7.2	132.65	25.24
7.3	134.21	25.12
7.4	135.77	25.01
7.5	137.33	24.90
7.6	138.88	24.80
7.7	140.44	24.72
7.8	142.00	24.63
7.9	143.55	24.56
8.0	145.11	24.50
8.1	146.67	24.44
8.2	148.23	24.39
8.3	149.78	24.35
8.4	151.34	24.32
8.5	152.90	24.29
8.6	154.45	24.28
8.7	156.01	24.27
8.8	157.57	24.27
8.9	159.13	24.28
9.0	160.68	24.30
9.1	162.24	24.32
9.2	163.80	24.36
9.3	165.35	24.40
9.4	166.91	24.45
9.5	168.47	24.51
9.6	170.03	24.57
9.7	171.58	24.65
9.8	173.14	24.73
9.9	174.70	24.82
10.0	176.26	24.92

CONTINUED . . .

APPENDIX 9 CONTINUED

1968 TREE 8 TSCN = Y = -31.423 + 11.531X1 + 3.707X2

X1 = RH1	X2 = ORD									
	4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
5.0	41.06	25.85	44.77	23.28	48.47	21.91	52.18	21.95	55.89	23.40
5.5	46.83	24.67	50.53	21.75	54.24	20.03	57.95	19.83	61.65	21.20
6.0	52.59	23.71	56.30	20.41	60.01	18.30	63.71	17.81	67.42	19.06
6.5	58.36	22.98	62.06	19.30	65.77	16.77	69.48	15.93	73.19	17.03
7.0	64.12	22.50	67.83	18.47	71.54	15.49	75.24	14.23	78.95	15.14
7.5	69.89	22.29	73.60	17.94	77.30	14.53	81.01	12.80	84.72	13.44
8.0	75.65	22.36	79.36	17.76	83.07	13.95	86.78	11.74	90.48	12.03
8.5	81.42	22.71	85.13	17.92	88.83	13.81	92.54	11.14	96.25	11.01
9.0	87.19	23.32	90.89	18.43	94.60	14.11	98.31	11.08	102.01	10.50
9.5	92.95	24.17	96.66	19.24	100.36	14.84	104.07	11.58	107.78	10.57
10.0	98.72	25.25	102.42	20.34	106.13	15.93	109.84	12.56	113.54	11.21
10.5								ORD 9 =	123.02	13.19

APPENDIX 10

TABLES FOR ESTIMATION OF THE NUMBER OF CENTRAL SCALES (CSCN) IN A CONE FROM THE TOTAL NUMBER OF SCALES (TSCN) IN THE CONE

Tables are provided only for those trees for which sufficient data were obtained to produce significant regressions. Tables are therefore included for trees 1 to 10, 1964, for trees 1 to 12, 1966 and for trees 1,2, 4 to 9, 1968. (The regressions are illustrated in Fig. 4. 18.)

APPENDIX 10

1964 TREE 1 CSCN = Y = -44.716 + 1.030TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	17.11	18.14	19.18	20.21	21.24	22.27	23.30	24.33	25.36	26.39
+-	20.51	20.47	20.43	20.39	20.35	20.32	20.28	20.24	20.21	20.17
70	27.42	28.45	29.48	30.51	31.54	32.57	33.60	34.63	35.66	36.69
+-	20.14	20.10	20.06	20.03	20.00	19.96	19.93	19.89	19.86	19.83
80	37.72	38.75	39.79	40.82	41.85	42.88	43.91	44.94	45.97	47.00
+-	19.80	19.76	19.73	19.70	19.67	19.64	19.61	19.58	19.55	19.52
90	48.03	49.06	50.09	51.12	52.15	53.18	54.21	55.24	56.27	57.30
+-	19.49	19.47	19.44	19.41	19.38	19.36	19.33	19.31	19.28	19.26
100	58.33	59.36	60.40	61.43	62.46	63.49	64.52	65.55	66.58	67.61
+-	19.23	19.21	19.18	19.16	19.14	19.11	19.09	19.07	19.05	19.03
110	68.64	69.67	70.70	71.73	72.76	73.79	74.82	75.85	76.88	77.91
+-	19.01	18.99	18.97	18.95	18.93	18.91	18.89	18.87	18.86	18.84
120	78.94	79.97	81.01	82.04	83.07	84.10	85.13	86.16	87.19	88.22
+-	18.82	18.81	18.79	18.78	18.76	18.75	18.73	18.72	18.71	18.69
130	89.25	90.28	91.31	92.34	93.37	94.40	95.43	96.46	97.49	98.52
+-	18.68	18.67	18.66	18.65	18.64	18.63	18.62	18.61	18.60	18.59
140	99.55	100.58	101.62	102.65	103.68	104.71	105.74	106.77	107.80	108.83
+-	18.58	18.58	18.57	18.56	18.56	18.55	18.55	18.54	18.54	18.53
150	109.86	110.89	111.92	112.95	113.98	115.01	116.04	117.07	118.10	119.13
+-	18.53	18.53	18.53	18.52	18.52	18.52	18.52	18.52	18.52	18.52
160	120.16	121.19	122.23	123.26	124.29	125.32	126.35	127.38	128.41	129.44
+-	18.52	18.52	18.52	18.53	18.53	18.53	18.54	18.54	18.55	18.55
170	130.47	131.50	132.53	133.56	134.59	135.62	136.65	137.68	138.71	139.74
+-	18.56	18.56	18.57	18.57	18.58	18.59	18.60	18.61	18.61	18.62
180	140.77	141.80	142.84	143.87	144.90	145.93	146.96	147.99	149.02	150.05
+-	18.63	18.64	18.66	18.67	18.68	18.69	18.70	18.72	18.73	18.74
190	151.08	152.11	153.14	154.17	155.20	156.23	157.26	158.29	159.32	160.35
+-	18.76	18.77	18.79	18.80	18.82	18.83	18.85	18.87	18.88	18.90
200	161.38	162.41	163.45	164.48	165.51	166.54	167.57	168.60	169.63	170.66
+-	18.92	18.94	18.96	18.98	19.00	19.02	19.04	19.06	19.08	19.11
210	171.69	172.72	173.75	174.78	175.81	176.84	177.87	178.90	179.93	180.96
+-	19.13	19.15	19.17	19.20	19.22	19.25	19.27	19.30	19.32	19.35

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 2 CSCN = Y = -30.170 + 1.002TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	29.94	30.94	31.94	32.94	33.94	34.94	35.95	36.95	37.95	38.95
+-	9.76	9.73	9.71	9.69	9.66	9.64	9.62	9.60	9.57	9.55
70	39.95	40.95	41.96	42.96	43.96	44.96	45.96	46.97	47.97	48.97
+-	9.53	9.51	9.49	9.47	9.45	9.43	9.41	9.40	9.38	9.36
80	49.97	50.97	51.97	52.98	53.98	54.98	55.98	56.98	57.98	58.99
+-	9.34	9.33	9.31	9.30	9.28	9.27	9.25	9.24	9.22	9.21
90	59.99	60.99	61.99	62.99	63.99	65.00	66.00	67.00	68.00	69.00
+-	9.20	9.19	9.17	9.16	9.15	9.14	9.13	9.12	9.11	9.11
100	70.01	71.01	72.01	73.01	74.01	75.01	76.02	77.02	78.02	79.02
+-	9.10	9.09	9.08	9.08	9.07	9.06	9.06	9.05	9.05	9.05
110	80.02	81.02	82.03	83.03	84.03	85.03	86.03	87.04	88.04	89.04
+-	9.04	9.04	9.04	9.04	9.03	9.03	9.03	9.03	9.03	9.03
120	90.04	91.04	92.04	93.05	94.05	95.05	96.05	97.05	98.05	99.06
+-	9.03	9.04	9.04	9.04	9.04	9.05	9.05	9.06	9.06	9.07
130	100.06	101.06	102.06	103.06	104.07	105.07	106.07	107.07	108.07	109.07
+-	9.07	9.08	9.09	9.09	9.10	9.11	9.12	9.13	9.14	9.15
140	110.08	111.08	112.08	113.08	114.08	115.08	116.09	117.09	118.09	119.09
+-	9.16	9.17	9.18	9.19	9.20	9.22	9.23	9.24	9.26	9.27
150	120.09	121.10	122.10	123.10	124.10	125.10	126.10	127.11	128.11	129.11
+-	9.29	9.30	9.32	9.33	9.35	9.37	9.38	9.40	9.42	9.44
160	130.11	131.11	132.11	133.12	134.12	135.12	136.12	137.12	138.13	139.13
+-	9.46	9.48	9.50	9.52	9.54	9.56	9.58	9.60	9.63	9.65
170	140.13	141.13	142.13	143.13	144.14	145.14	146.14	147.14	148.14	149.14
+-	9.67	9.69	9.72	9.74	9.77	9.79	9.82	9.84	9.87	9.90
180	150.15	151.15	152.15	153.15	154.15	155.16	156.16	157.16	158.16	159.16
+-	9.92	9.95	9.98	10.00	10.03	10.06	10.09	10.12	10.15	10.18
190	160.16	161.17	162.17	163.17	164.17	165.17	166.17	167.18	168.18	169.18
+-	10.21	10.24	10.27	10.30	10.33	10.36	10.40	10.43	10.46	10.49
200	170.18	171.18	172.19	173.19	174.19	175.19	176.19	177.19	178.20	179.20
+-	10.53	10.56	10.59	10.63	10.66	10.70	10.73	10.77	10.80	10.84
210	180.20	181.20	182.20	183.20	184.21	185.21	186.21	187.21	188.21	189.21
+-	10.88	10.91	10.95	10.99	11.02	11.06	11.10	11.14	11.17	11.21

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 3 CSCN = Y = -25.673 + 0.952TSCN

TSCN		0	1	2	3	4	5	6	7	8	9
60		31.47	32.43	33.38	34.33	35.28	36.24	37.19	38.14	39.09	40.05
	+-	16.00	15.91	15.81	15.72	15.62	15.53	15.44	15.35	15.25	15.16
70		41.00	41.95	42.90	43.86	44.81	45.76	46.71	47.67	48.62	49.57
	+-	15.07	14.98	14.90	14.81	14.72	14.64	14.55	14.47	14.38	14.30
80		50.52	51.48	52.43	53.38	54.33	55.29	56.24	57.19	58.14	59.09
	+-	14.22	14.14	14.06	13.98	13.90	13.83	13.75	13.67	13.60	13.53
90		60.05	61.00	61.95	62.90	63.86	64.81	65.76	66.71	67.67	68.62
	+-	13.46	13.38	13.32	13.25	13.18	13.11	13.05	12.98	12.92	12.86
100		69.57	70.52	71.48	72.43	73.38	74.33	75.29	76.24	77.19	78.14
	+-	12.80	12.74	12.68	12.62	12.57	12.51	12.46	12.41	12.36	12.31
110		79.10	80.05	81.00	81.95	82.91	83.86	84.81	85.76	86.72	87.67
	+-	12.26	12.22	12.17	12.13	12.09	12.05	12.01	11.97	11.94	11.90
120		88.62	89.57	90.53	91.48	92.43	93.38	94.34	95.29	96.24	97.19
	+-	11.87	11.84	11.81	11.78	11.75	11.73	11.71	11.68	11.66	11.65
130		98.15	99.10	100.05	101.00	101.96	102.91	103.86	104.81	105.76	106.72
	+-	11.63	11.61	11.60	11.59	11.58	11.57	11.56	11.56	11.55	11.55
140		107.67	108.62	109.57	110.53	111.48	112.43	113.38	114.34	115.29	116.24
	+-	11.55	11.55	11.56	11.56	11.57	11.58	11.59	11.60	11.61	11.63
150		117.19	118.15	119.10	120.05	121.00	121.96	122.91	123.86	124.81	125.77
	+-	11.64	11.66	11.68	11.70	11.72	11.75	11.78	11.80	11.83	11.86
160		126.72	127.67	128.62	129.58	130.53	131.48	132.43	133.39	134.34	135.29
	+-	11.90	11.93	11.97	12.00	12.04	12.08	12.12	12.17	12.21	12.26
170		136.24	137.20	138.15	139.10	140.05	141.01	141.96	142.91	143.86	144.82
	+-	12.30	12.35	12.40	12.45	12.51	12.56	12.61	12.67	12.73	12.79
180		145.77	146.72	147.67	148.63	149.58	150.53	151.48	152.43	153.39	154.34
	+-	12.85	12.91	12.97	13.04	13.10	13.17	13.23	13.30	13.37	13.44
190		155.29	156.24	157.20	158.15	159.10	160.05	161.01	161.96	162.91	163.86
	+-	13.52	13.59	13.66	13.74	13.81	13.89	13.97	14.05	14.13	14.21
200		164.82	165.77	166.72	167.67	168.63	169.58	170.53	171.48	172.44	173.39
	+-	14.29	14.37	14.45	14.54	14.62	14.71	14.79	14.88	14.97	15.06
210		174.34	175.29	176.25	177.20	178.15	179.10	180.06	181.01	181.96	182.91
	+-	15.15	15.24	15.33	15.42	15.51	15.61	15.70	15.80	15.89	15.99

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 4 CSCN = Y = -24.428 + 0.944TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	32.19	33.13	34.08	35.02	35.96	36.91	37.85	38.79	39.74	40.68
+-	12.95	12.94	12.94	12.93	12.92	12.91	12.90	12.90	12.89	12.88
70	41.62	42.57	43.51	44.46	45.40	46.34	47.29	48.23	49.17	50.12
+-	12.87	12.87	12.86	12.85	12.84	12.84	12.83	12.82	12.82	12.81
80	51.06	52.00	52.95	53.89	54.83	55.78	56.72	57.67	58.61	59.55
+-	12.81	12.80	12.79	12.79	12.78	12.78	12.77	12.77	12.76	12.76
90	60.50	61.44	62.38	63.33	64.27	65.21	66.16	67.10	68.04	68.99
+-	12.75	12.75	12.74	12.74	12.73	12.73	12.72	12.72	12.71	12.71
100	69.93	70.88	71.82	72.76	73.71	74.65	75.59	76.54	77.48	78.42
+-	12.71	12.70	12.70	12.70	12.69	12.69	12.69	12.68	12.68	12.68
110	79.37	80.31	81.26	82.20	83.14	84.09	85.03	85.97	86.92	87.86
+-	12.67	12.67	12.67	12.67	12.67	12.66	12.66	12.66	12.66	12.66
120	88.80	89.75	90.69	91.63	92.58	93.52	94.47	95.41	96.35	97.30
+-	12.66	12.65	12.65	12.65	12.65	12.65	12.65	12.65	12.65	12.65
130	98.24	99.18	100.13	101.07	102.01	102.96	103.90	104.85	105.79	106.73
+-	12.65	12.65	12.65	12.65	12.65	12.65	12.65	12.65	12.65	12.65
140	107.68	108.62	109.56	110.51	111.45	112.39	113.34	114.28	115.22	116.17
+-	12.65	12.66	12.66	12.66	12.66	12.66	12.66	12.67	12.67	12.67
150	117.11	118.06	119.00	119.94	120.89	121.83	122.77	123.72	124.66	125.60
+-	12.67	12.67	12.68	12.68	12.68	12.69	12.69	12.69	12.69	12.70
160	126.55	127.49	128.44	129.38	130.32	131.27	132.21	133.15	134.10	135.04
+-	12.70	12.71	12.71	12.71	12.72	12.72	12.73	12.73	12.73	12.74
170	135.98	136.93	137.87	138.82	139.76	140.70	141.65	142.59	143.53	144.48
+-	12.74	12.75	12.75	12.76	12.76	12.77	12.77	12.78	12.79	12.79
180	145.42	146.36	147.31	148.25	149.19	150.14	151.08	152.03	152.97	153.91
+-	12.80	12.80	12.81	12.82	12.82	12.83	12.84	12.84	12.85	12.86
190	154.86	155.80	156.74	157.69	158.63	159.57	160.52	161.46	162.40	163.35
+-	12.86	12.87	12.88	12.89	12.89	12.90	12.91	12.92	12.93	12.93
200	164.29	165.24	166.18	167.12	168.07	169.01	169.95	170.90	171.84	172.78
+-	12.94	12.95	12.96	12.97	12.98	12.99	12.99	13.00	13.01	13.02
210	173.73	174.67	175.62	176.56	177.50	178.45	179.39	180.33	181.28	182.22
+-	13.03	13.04	13.05	13.06	13.07	13.08	13.09	13.10	13.11	13.12

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 5 CSCN = Y = -41.122 + 1.020TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	20.08	21.10	22.12	23.14	24.16	25.18	26.20	27.22	28.24	29.26
+-	19.06	19.03	19.00	18.98	18.95	18.92	18.90	18.87	18.85	18.82
70	30.28	31.30	32.32	33.34	34.36	35.38	36.40	37.42	38.44	39.46
+-	18.80	18.78	18.75	18.73	18.70	18.68	18.66	18.64	18.61	18.59
80	40.48	41.50	42.52	43.54	44.56	45.58	46.60	47.62	48.64	49.66
+-	18.57	18.55	18.53	18.51	18.48	18.46	18.44	18.42	18.41	18.39
90	50.68	51.70	52.72	53.74	54.76	55.78	56.80	57.82	58.84	59.86
+-	18.37	18.35	18.33	18.31	18.29	18.28	18.26	18.24	18.23	18.21
100	60.88	61.90	62.92	63.94	64.96	65.98	67.00	68.02	69.04	70.06
+-	18.19	18.18	18.16	18.15	18.13	18.12	18.10	18.09	18.08	18.06
110	71.08	72.10	73.12	74.14	75.16	76.18	77.20	78.22	79.24	80.26
+-	18.05	18.04	18.02	18.01	18.00	17.99	17.98	17.97	17.96	17.95
120	81.28	82.30	83.32	84.34	85.36	86.38	87.40	88.42	89.44	90.46
+-	17.94	17.93	17.92	17.91	17.90	17.89	17.88	17.87	17.87	17.86
130	91.48	92.50	93.52	94.54	95.56	96.58	97.60	98.62	99.64	100.66
+-	17.85	17.85	17.84	17.83	17.83	17.82	17.82	17.81	17.81	17.80
140	101.68	102.70	103.72	104.74	105.76	106.78	107.80	108.82	109.84	110.86
+-	17.80	17.80	17.79	17.79	17.79	17.79	17.78	17.78	17.78	17.78
150	111.88	112.90	113.92	114.94	115.96	116.98	118.00	119.02	120.04	121.06
+-	17.78	17.78	17.78	17.78	17.78	17.78	17.78	17.78	17.79	17.79
160	122.08	123.10	124.12	125.14	126.16	127.18	128.20	129.22	130.24	131.26
+-	17.79	17.79	17.80	17.80	17.80	17.81	17.81	17.82	17.82	17.83
170	132.28	133.30	134.32	135.34	136.36	137.38	138.40	139.42	140.44	141.46
+-	17.83	17.84	17.85	17.85	17.86	17.87	17.87	17.88	17.89	17.90
180	142.48	143.50	144.52	145.54	146.56	147.58	148.60	149.62	150.64	151.66
+-	17.91	17.92	17.93	17.94	17.95	17.96	17.97	17.98	17.99	18.00
190	152.68	153.70	154.72	155.74	156.76	157.78	158.80	159.82	160.84	161.86
+-	18.01	18.02	18.04	18.05	18.06	18.08	18.09	18.10	18.12	18.13
200	162.88	163.90	164.92	165.94	166.96	167.98	169.00	170.02	171.04	172.06
+-	18.15	18.16	18.18	18.19	18.21	18.23	18.24	18.26	18.28	18.29
210	173.08	174.10	175.12	176.14	177.16	178.18	179.20	180.22	181.24	182.26
+-	18.31	18.33	18.35	18.37	18.39	18.41	18.42	18.44	18.46	18.48

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 6 CSCN = Y = -37.785 + 0.979TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	20.97	21.95	22.93	23.90	24.88	25.86	26.84	27.82	28.80	29.78
+-	8.41	8.31	8.22	8.12	8.03	7.93	7.83	7.74	7.64	7.55
70	30.76	31.74	32.72	33.70	34.68	35.65	36.63	37.61	38.59	39.57
+-	7.45	7.36	7.26	7.17	7.08	6.98	6.89	6.80	6.70	6.61
80	40.55	41.53	42.51	43.49	44.47	45.45	46.43	47.40	48.38	49.36
+-	6.52	6.43	6.34	6.25	6.16	6.07	5.98	5.89	5.80	5.71
90	50.34	51.32	52.30	53.28	54.26	55.24	56.22	57.20	58.18	59.16
+-	5.63	5.54	5.45	5.37	5.29	5.20	5.12	5.04	4.96	4.88
100	60.13	61.11	62.09	63.07	64.05	65.03	66.01	66.99	67.97	68.95
+-	4.80	4.72	4.64	4.57	4.49	4.42	4.34	4.27	4.20	4.13
110	69.93	70.91	71.88	72.86	73.84	74.82	75.80	76.78	77.76	78.74
+-	4.07	4.00	3.94	3.88	3.82	3.76	3.70	3.65	3.60	3.55
120	79.72	80.70	81.68	82.66	83.63	84.61	85.59	86.57	87.55	88.53
+-	3.50	3.46	3.42	3.38	3.34	3.31	3.28	3.25	3.23	3.21
130	89.51	90.49	91.47	92.45	93.43	94.41	95.39	96.36	97.34	98.32
+-	3.19	3.18	3.17	3.16	3.16	3.16	3.16	3.17	3.18	3.19
140	99.30	100.28	101.26	102.24	103.22	104.20	105.18	106.16	107.14	108.11
+-	3.21	3.23	3.25	3.28	3.31	3.34	3.38	3.42	3.46	3.50
150	109.09	110.07	111.05	112.03	113.01	113.99	114.97	115.95	116.93	117.91
+-	3.55	3.60	3.65	3.70	3.76	3.82	3.88	3.94	4.00	4.07
160	118.89	119.86	120.84	121.82	122.80	123.78	124.76	125.74	126.72	127.70
+-	4.13	4.20	4.27	4.34	4.42	4.49	4.57	4.64	4.72	4.80
170	128.68	129.66	130.64	131.62	132.59	133.57	134.55	135.53	136.51	137.49
+-	4.88	4.96	5.04	5.12	5.20	5.29	5.37	5.45	5.54	5.63
180	138.47	139.45	140.43	141.41	142.39	143.37	144.34	145.32	146.30	147.28
+-	5.71	5.80	5.89	5.98	6.07	6.16	6.25	6.34	6.43	6.52
190	148.26	149.24	150.22	151.20	152.18	153.16	154.14	155.12	156.10	157.07
+-	6.61	6.70	6.80	6.89	6.98	7.08	7.17	7.26	7.36	7.45
200	158.05	159.03	160.01	160.99	161.97	162.95	163.93	164.91	165.89	166.87
+-	7.55	7.64	7.74	7.83	7.93	8.03	8.12	8.22	8.31	8.41
210	167.85	168.82	169.80	170.78	171.76	172.74	173.72	174.70	175.68	176.66
+-	8.51	8.61	8.70	8.80	8.90	9.00	9.09	9.19	9.29	9.39

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 7 CSCN = Y = -20.558 + 0.924TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	34.88	35.81	36.73	37.66	38.58	39.50	40.43	41.35	42.28	43.20
+-	17.29	17.22	17.16	17.10	17.04	16.99	16.93	16.87	16.81	16.76
70	44.12	45.05	45.97	46.90	47.82	48.74	49.67	50.59	51.52	52.44
+-	16.70	16.65	16.59	16.54	16.48	16.43	16.38	16.33	16.28	16.23
80	53.36	54.29	55.21	56.14	57.06	57.98	58.91	59.83	60.76	61.68
+-	16.18	16.13	16.08	16.03	15.99	15.94	15.90	15.85	15.81	15.77
90	62.60	63.53	64.45	65.38	66.30	67.22	68.15	69.07	70.00	70.92
+-	15.73	15.68	15.64	15.60	15.56	15.53	15.49	15.45	15.42	15.38
100	71.84	72.77	73.69	74.62	75.54	76.46	77.39	78.31	79.24	80.16
+-	15.35	15.31	15.28	15.25	15.22	15.19	15.16	15.13	15.10	15.08
110	81.08	82.01	82.93	83.86	84.78	85.70	86.63	87.55	88.48	89.40
+-	15.05	15.03	15.00	14.98	14.96	14.93	14.91	14.89	14.88	14.86
120	90.32	91.25	92.17	93.10	94.02	94.94	95.87	96.79	97.72	98.64
+-	14.84	14.82	14.81	14.79	14.78	14.77	14.76	14.75	14.74	14.73
130	99.56	100.49	101.41	102.34	103.26	104.18	105.11	106.03	106.96	107.88
+-	14.72	14.71	14.71	14.70	14.70	14.69	14.69	14.69	14.69	14.69
140	108.81	109.73	110.65	111.58	112.50	113.43	114.35	115.27	116.20	117.12
+-	14.69	14.69	14.70	14.70	14.71	14.71	14.72	14.73	14.73	14.74
150	118.05	118.97	119.89	120.82	121.74	122.67	123.59	124.51	125.44	126.36
+-	14.75	14.77	14.78	14.79	14.81	14.82	14.84	14.85	14.87	14.89
160	127.29	128.21	129.13	130.06	130.98	131.91	132.83	133.75	134.68	135.60
+-	14.91	14.93	14.95	14.97	15.00	15.02	15.05	15.07	15.10	15.12
170	136.53	137.45	138.37	139.30	140.22	141.15	142.07	142.99	143.92	144.84
+-	15.15	15.18	15.21	15.24	15.27	15.31	15.34	15.37	15.41	15.44
180	145.77	146.69	147.61	148.54	149.46	150.39	151.31	152.23	153.16	154.08
+-	15.48	15.52	15.56	15.59	15.63	15.67	15.72	15.76	15.80	15.84
190	155.01	155.93	156.85	157.78	158.70	159.63	160.55	161.47	162.40	163.32
+-	15.89	15.93	15.98	16.02	16.07	16.12	16.17	16.22	16.27	16.32
200	164.25	165.17	166.09	167.02	167.94	168.87	169.79	170.71	171.64	172.56
+-	16.37	16.42	16.47	16.52	16.58	16.63	16.69	16.74	16.80	16.86
210	173.49	174.41	175.33	176.26	177.18	178.11	179.03	179.95	180.88	181.80
+-	16.91	16.97	17.03	17.09	17.15	17.21	17.27	17.33	17.39	17.46

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 8 CSCN = Y = -20.860 + 0.938TSCN

TSCN		0	1	2	3	4	5	6	7	8	9
60		35.39	36.33	37.27	38.21	39.14	40.08	41.02	41.96	42.89	43.83
	+-	22.59	22.27	21.95	21.63	21.32	21.00	20.69	20.38	20.07	19.77
70		44.77	45.71	46.64	47.58	48.52	49.46	50.39	51.33	52.27	53.21
	+-	19.46	19.16	18.86	18.57	18.27	17.98	17.69	17.41	17.12	16.85
80		54.14	55.08	56.02	56.96	57.89	58.83	59.77	60.71	61.64	62.58
	+-	16.57	16.30	16.03	15.77	15.51	15.25	15.00	14.76	14.52	14.29
90		63.52	64.46	65.39	66.33	67.27	68.21	69.15	70.08	71.02	71.96
	+-	14.06	13.83	13.62	13.41	13.21	13.01	12.83	12.65	12.47	12.31
100		72.90	73.83	74.77	75.71	76.65	77.58	78.52	79.46	80.40	81.33
	+-	12.16	12.02	11.88	11.76	11.64	11.54	11.45	11.37	11.30	11.24
110		82.27	83.21	84.15	85.08	86.02	86.96	87.90	88.83	89.77	90.71
	+-	11.20	11.16	11.14	11.13	11.13	11.15	11.18	11.22	11.27	11.33
120		91.65	92.58	93.52	94.46	95.40	96.33	97.27	98.21	99.15	100.08
	+-	11.40	11.49	11.59	11.70	11.81	11.94	12.08	12.23	12.39	12.55
130		101.02	101.96	102.90	103.83	104.77	105.71	106.65	107.58	108.52	109.46
	+-	12.73	12.91	13.10	13.30	13.51	13.72	13.94	14.16	14.39	14.63
140		110.40	111.33	112.27	113.21	114.15	115.09	116.02	116.96	117.90	118.84
	+-	14.87	15.12	15.37	15.63	15.89	16.16	16.43	16.70	16.98	17.26
150		119.77	120.71	121.65	122.59	123.52	124.46	125.40	126.34	127.27	128.21
	+-	17.54	17.83	18.12	18.41	18.70	19.00	19.30	19.60	19.91	20.22
160		129.15	130.09	131.02	131.96	132.90	133.84	134.77	135.71	136.65	137.59
	+-	20.52	20.84	21.15	21.46	21.78	22.10	22.42	22.74	23.06	23.38
170		138.52	139.46	140.40	141.34	142.27	143.21	144.15	145.09	146.02	146.96
	+-	23.71	24.04	24.36	24.69	25.02	25.35	25.69	26.02	26.35	26.69
180		147.90	148.84	149.77	150.71	151.65	152.59	153.52	154.46	155.40	156.34
	+-	27.02	27.36	27.70	28.04	28.38	28.72	29.06	29.40	29.74	30.08
190		157.27	158.21	159.15	160.09	161.02	161.96	162.90	163.84	164.78	165.71
	+-	30.42	30.77	31.11	31.46	31.80	32.15	32.50	32.84	33.19	33.54
200		166.65	167.59	168.53	169.46	170.40	171.34	172.28	173.21	174.15	175.09
	+-	33.89	34.23	34.58	34.93	35.28	35.63	35.98	36.34	36.69	37.04
210		176.03	176.96	177.90	178.84	179.78	180.71	181.65	182.59	183.53	184.46
	+-	37.39	37.74	38.10	38.45	38.80	39.16	39.51	39.86	40.22	40.57

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 9 CSCN = Y = -9.075 + 0.766TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	36.87	37.64	38.40	39.17	39.93	40.70	41.46	42.23	43.00	43.76
+-	9.23	9.15	9.07	8.99	8.91	8.84	8.76	8.68	8.61	8.53
70	44.53	45.29	46.06	46.82	47.59	48.36	49.12	49.89	50.65	51.42
+-	8.46	8.38	8.31	8.24	8.16	8.09	8.02	7.95	7.88	7.82
80	52.18	52.95	53.72	54.48	55.25	56.01	56.78	57.55	58.31	59.08
+-	7.75	7.68	7.62	7.55	7.49	7.42	7.36	7.30	7.24	7.18
90	59.84	60.61	61.37	62.14	62.91	63.67	64.44	65.20	65.97	66.73
+-	7.12	7.06	7.01	6.95	6.90	6.85	6.80	6.74	6.70	6.65
100	67.50	68.27	69.03	69.80	70.56	71.33	72.09	72.86	73.63	74.39
+-	6.60	6.56	6.51	6.47	6.43	6.39	6.35	6.31	6.28	6.25
110	75.16	75.92	76.69	77.45	78.22	78.99	79.75	80.52	81.28	82.05
+-	6.21	6.18	6.15	6.13	6.10	6.08	6.05	6.03	6.02	6.00
120	82.81	83.58	84.35	85.11	85.88	86.64	87.41	88.18	88.94	89.71
+-	5.98	5.97	5.96	5.95	5.94	5.93	5.93	5.93	5.93	5.93
130	90.47	91.24	92.00	92.77	93.54	94.30	95.07	95.83	96.60	97.36
+-	5.93	5.93	5.94	5.95	5.96	5.97	5.98	6.00	6.02	6.04
140	98.13	98.90	99.66	100.43	101.19	101.96	102.72	103.49	104.26	105.02
+-	6.06	6.08	6.10	6.13	6.16	6.19	6.22	6.25	6.28	6.32
150	105.79	106.55	107.32	108.08	108.85	109.62	110.38	111.15	111.91	112.68
+-	6.35	6.39	6.43	6.47	6.52	6.56	6.61	6.65	6.70	6.75
160	113.44	114.21	114.98	115.74	116.51	117.27	118.04	118.81	119.57	120.34
+-	6.80	6.85	6.90	6.96	7.01	7.07	7.13	7.19	7.25	7.31
170	121.10	121.87	122.63	123.40	124.17	124.93	125.70	126.46	127.23	127.99
+-	7.37	7.43	7.49	7.56	7.62	7.69	7.75	7.82	7.89	7.96
180	128.76	129.53	130.29	131.06	131.82	132.59	133.35	134.12	134.89	135.65
+-	8.03	8.10	8.17	8.24	8.32	8.39	8.46	8.54	8.61	8.69
190	136.42	137.18	137.95	138.71	139.48	140.25	141.01	141.78	142.54	143.31
+-	8.77	8.84	8.92	9.00	9.08	9.16	9.24	9.32	9.40	9.48
200	144.07	144.84	145.61	146.37	147.14	147.90	148.67	149.44	150.20	150.97
+-	9.56	9.64	9.72	9.81	9.89	9.97	10.06	10.14	10.23	10.31
210	151.73	152.50	153.26	154.03	154.80	155.56	156.33	157.09	157.86	158.62
+-	10.40	10.48	10.57	10.65	10.74	10.83	10.92	11.00	11.09	11.18

CONTINUED . . .

APPENDIX 10 CONTINUED

1964 TREE 10 CSCN = Y = -28.594 + 0.989TSCN

TSCN		0	1	2	3	4	5	6	7	8	9
60		30.76	31.75	32.74	33.73	34.72	35.70	36.69	37.68	38.67	39.66
	+-	9.23	9.15	9.06	8.98	8.89	8.81	8.73	8.65	8.57	8.49
70		40.65	41.64	42.63	43.62	44.61	45.60	46.59	47.58	48.56	49.55
	+-	8.41	8.33	8.25	8.18	8.10	8.03	7.95	7.88	7.81	7.74
80		50.54	51.53	52.52	53.51	54.50	55.49	56.48	57.47	58.46	59.45
	+-	7.67	7.60	7.53	7.46	7.40	7.33	7.27	7.21	7.15	7.09
90		60.43	61.42	62.41	63.40	64.39	65.38	66.37	67.36	68.35	69.34
	+-	7.03	6.98	6.92	6.87	6.82	6.76	6.72	6.67	6.62	6.58
100		70.33	71.32	72.31	73.29	74.28	75.27	76.26	77.25	78.24	79.23
	+-	6.54	6.49	6.46	6.42	6.38	6.35	6.32	6.29	6.26	6.23
110		80.22	81.21	82.20	83.19	84.18	85.17	86.15	87.14	88.13	89.12
	+-	6.21	6.19	6.17	6.15	6.13	6.12	6.11	6.10	6.09	6.09
120		90.11	91.10	92.09	93.08	94.07	95.06	96.05	97.04	98.02	99.01
	+-	6.08	6.08	6.08	6.09	6.09	6.10	6.11	6.12	6.13	6.15
130		100.00	100.99	101.98	102.97	103.96	104.95	105.94	106.93	107.92	108.91
	+-	6.17	6.19	6.21	6.23	6.26	6.29	6.32	6.35	6.38	6.42
140		109.90	110.88	111.87	112.86	113.85	114.84	115.83	116.82	117.81	118.80
	+-	6.46	6.49	6.54	6.58	6.62	6.67	6.72	6.76	6.82	6.87
150		119.79	120.78	121.77	122.76	123.74	124.73	125.72	126.71	127.70	128.69
	+-	6.92	6.98	7.03	7.09	7.15	7.21	7.27	7.33	7.40	7.46
160		129.68	130.67	131.66	132.65	133.64	134.63	135.61	136.60	137.59	138.58
	+-	7.53	7.60	7.67	7.74	7.81	7.88	7.95	8.03	8.10	8.18
170		139.57	140.56	141.55	142.54	143.53	144.52	145.51	146.50	147.49	148.47
	+-	8.25	8.33	8.41	8.49	8.57	8.65	8.73	8.81	8.89	8.98
180		149.46	150.45	151.44	152.43	153.42	154.41	155.40	156.39	157.38	158.37
	+-	9.06	9.15	9.23	9.32	9.41	9.49	9.58	9.67	9.76	9.85
190		159.36	160.35	161.33	162.32	163.31	164.30	165.29	166.28	167.27	168.26
	+-	9.94	10.03	10.12	10.21	10.30	10.39	10.48	10.58	10.67	10.76
200		169.25	170.24	171.23	172.22	173.20	174.19	175.18	176.17	177.16	178.15
	+-	10.86	10.95	11.05	11.14	11.24	11.33	11.43	11.53	11.62	11.72
210		179.14	180.13	181.12	182.11	183.10	184.09	185.08	186.06	187.05	188.04
	+-	11.82	11.92	12.02	12.11	12.21	12.31	12.41	12.51	12.61	12.71

CONTINUED . . .

APPENDIX 10 CONTINUED

1966 TREE 1 CSCN = Y = -15.269 + 0.904TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	39.00	39.91	40.81	41.71	42.62	43.52	44.43	45.33	46.24	47.14
+-	11.33	11.32	11.30	11.29	11.28	11.26	11.25	11.24	11.23	11.22
70	48.05	48.95	49.85	50.76	51.66	52.57	53.47	54.38	55.28	56.19
+-	11.20	11.19	11.18	11.17	11.16	11.15	11.13	11.12	11.11	11.10
80	57.09	57.99	58.90	59.80	60.71	61.61	62.52	63.42	64.33	65.23
+-	11.09	11.08	11.07	11.06	11.05	11.04	11.03	11.02	11.01	11.00
90	66.14	67.04	67.94	68.85	69.75	70.66	71.56	72.47	73.37	74.28
+-	10.99	10.98	10.97	10.96	10.95	10.94	10.94	10.93	10.92	10.91
100	75.18	76.08	76.99	77.89	78.80	79.70	80.61	81.51	82.42	83.32
+-	10.90	10.89	10.89	10.88	10.87	10.86	10.85	10.85	10.84	10.83
110	84.23	85.13	86.03	86.94	87.84	88.75	89.65	90.56	91.46	92.37
+-	10.83	10.82	10.81	10.81	10.80	10.79	10.79	10.78	10.77	10.77
120	93.27	94.17	95.08	95.98	96.89	97.79	98.70	99.60	100.51	101.41
+-	10.76	10.76	10.75	10.75	10.74	10.74	10.73	10.73	10.72	10.72
130	102.31	103.22	104.12	105.03	105.93	106.84	107.74	108.65	109.55	110.46
+-	10.71	10.71	10.71	10.70	10.70	10.69	10.69	10.69	10.68	10.68
140	111.36	112.26	113.17	114.07	114.98	115.88	116.79	117.69	118.60	119.50
+-	10.68	10.68	10.67	10.67	10.67	10.67	10.66	10.66	10.66	10.66
150	120.40	121.31	122.21	123.12	124.02	124.93	125.83	126.74	127.64	128.55
+-	10.66	10.66	10.65	10.65	10.65	10.65	10.65	10.65	10.65	10.65
160	129.45	130.35	131.26	132.16	133.07	133.97	134.88	135.78	136.69	137.59
+-	10.65	10.65	10.65	10.65	10.65	10.65	10.65	10.65	10.65	10.65
170	138.49	139.40	140.30	141.21	142.11	143.02	143.92	144.83	145.73	146.63
+-	10.65	10.66	10.66	10.66	10.66	10.66	10.66	10.67	10.67	10.67
180	147.54	148.44	149.35	150.25	151.16	152.06	152.97	153.87	154.78	155.68
+-	10.67	10.68	10.68	10.68	10.69	10.69	10.69	10.70	10.70	10.70
190	156.58	157.49	158.39	159.30	160.20	161.11	162.01	162.92	163.82	164.72
+-	10.71	10.71	10.72	10.72	10.72	10.73	10.73	10.74	10.74	10.75
200	165.63	166.53	167.44	168.34	169.25	170.15	171.06	171.96	172.87	173.77
+-	10.75	10.76	10.76	10.77	10.78	10.78	10.79	10.79	10.80	10.81
210	174.67	175.58	176.48	177.39	178.29	179.20	180.10	181.01	181.91	182.81
+-	10.81	10.82	10.83	10.83	10.84	10.85	10.86	10.86	10.87	10.88

CONTINUED . . .

APPENDIX 10 CONTINUED

1966 TREE 2 CSCN = Y = -6.230 + 0.857TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	45.18	46.03	46.89	47.75	48.60	49.46	50.32	51.17	52.03	52.89
+-	9.15	9.14	9.13	9.12	9.11	9.10	9.09	9.08	9.07	9.06
70	53.74	54.60	55.46	56.31	57.17	58.03	58.88	59.74	60.60	61.45
+-	9.05	9.04	9.03	9.02	9.01	9.00	9.00	8.99	8.98	8.97
80	62.31	63.17	64.02	64.88	65.74	66.59	67.45	68.31	69.16	70.02
+-	8.96	8.96	8.95	8.94	8.93	8.93	8.92	8.91	8.91	8.90
90	70.88	71.73	72.59	73.45	74.31	75.16	76.02	76.88	77.73	78.59
+-	8.90	8.89	8.88	8.88	8.87	8.87	8.86	8.86	8.85	8.85
100	79.45	80.30	81.16	82.02	82.87	83.73	84.59	85.44	86.30	87.16
+-	8.85	8.84	8.84	8.83	8.83	8.83	8.82	8.82	8.82	8.82
110	88.01	88.87	89.73	90.58	91.44	92.30	93.15	94.01	94.87	95.72
+-	8.81	8.81	8.81	8.81	8.81	8.81	8.80	8.80	8.80	8.80
120	96.58	97.44	98.29	99.15	100.01	100.86	101.72	102.58	103.43	104.29
+-	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80
130	105.15	106.01	106.86	107.72	108.58	109.43	110.29	111.15	112.00	112.86
+-	8.80	8.81	8.81	8.81	8.81	8.81	8.82	8.82	8.82	8.82
140	113.72	114.57	115.43	116.29	117.14	118.00	118.86	119.71	120.57	121.43
+-	8.83	8.83	8.83	8.84	8.84	8.85	8.85	8.85	8.86	8.86
150	122.28	123.14	124.00	124.85	125.71	126.57	127.42	128.28	129.14	129.99
+-	8.87	8.87	8.88	8.88	8.89	8.89	8.90	8.91	8.91	8.92
160	130.85	131.71	132.56	133.42	134.28	135.14	135.99	136.85	137.71	138.56
+-	8.93	8.93	8.94	8.95	8.95	8.96	8.97	8.98	8.99	8.99
170	139.42	140.28	141.13	141.99	142.85	143.70	144.56	145.42	146.27	147.13
+-	9.00	9.01	9.02	9.03	9.04	9.05	9.06	9.06	9.07	9.08
180	147.99	148.84	149.70	150.56	151.41	152.27	153.13	153.98	154.84	155.70
+-	9.09	9.10	9.11	9.13	9.14	9.15	9.16	9.17	9.18	9.19
190	156.55	157.41	158.27	159.12	159.98	160.84	161.69	162.55	163.41	164.26
+-	9.20	9.22	9.23	9.24	9.25	9.26	9.28	9.29	9.30	9.32
200	165.12	165.98	166.84	167.69	168.55	169.41	170.26	171.12	171.98	172.83
+-	9.33	9.34	9.36	9.37	9.38	9.40	9.41	9.43	9.44	9.45
210	173.69	174.55	175.40	176.26	177.12	177.97	178.83	179.69	180.54	181.40
+-	9.47	9.48	9.50	9.51	9.53	9.54	9.56	9.58	9.59	9.61

CONTINUED . . .

APPENDIX 10 CONTINUED

1966 TREE 3 CSCN = Y = -20.627 + 0.841TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	29.83	30.67	31.52	32.36	33.20	34.04	34.88	35.72	36.56	37.40
+-	13.86	13.81	13.76	13.71	13.67	13.62	13.57	13.53	13.48	13.43
70	38.24	39.08	39.93	40.77	41.61	42.45	43.29	44.13	44.97	45.81
+-	13.39	13.35	13.30	13.26	13.21	13.17	13.13	13.09	13.04	13.00
80	46.65	47.49	48.34	49.18	50.02	50.86	51.70	52.54	53.38	54.22
+-	12.96	12.92	12.88	12.84	12.80	12.76	12.72	12.69	12.65	12.61
90	55.06	55.90	56.75	57.59	58.43	59.27	60.11	60.95	61.79	62.63
+-	12.58	12.54	12.50	12.47	12.43	12.40	12.37	12.33	12.30	12.27
100	63.47	64.31	65.16	66.00	66.84	67.68	68.52	69.36	70.20	71.04
+-	12.24	12.20	12.17	12.14	12.11	12.08	12.06	12.03	12.00	11.97
110	71.88	72.72	73.57	74.41	75.25	76.09	76.93	77.77	78.61	79.45
+-	11.95	11.92	11.90	11.87	11.85	11.82	11.80	11.78	11.75	11.73
120	80.29	81.13	81.98	82.82	83.66	84.50	85.34	86.18	87.02	87.86
+-	11.71	11.69	11.67	11.65	11.63	11.62	11.60	11.58	11.56	11.55
130	88.70	89.54	90.39	91.23	92.07	92.91	93.75	94.59	95.43	96.27
+-	11.53	11.52	11.51	11.49	11.48	11.47	11.46	11.44	11.43	11.42
140	97.11	97.95	98.80	99.64	100.48	101.32	102.16	103.00	103.84	104.68
+-	11.42	11.41	11.40	11.39	11.39	11.38	11.37	11.37	11.37	11.36
150	105.52	106.36	107.21	108.05	108.89	109.73	110.57	111.41	112.25	113.09
+-	11.36	11.36	11.36	11.36	11.36	11.36	11.36	11.36	11.36	11.36
160	113.93	114.77	115.62	116.46	117.30	118.14	118.98	119.82	120.66	121.50
+-	11.37	11.37	11.38	11.38	11.39	11.39	11.40	11.41	11.42	11.43
170	122.34	123.18	124.03	124.87	125.71	126.55	127.39	128.23	129.07	129.91
+-	11.44	11.45	11.46	11.47	11.48	11.49	11.51	11.52	11.54	11.55
180	130.75	131.59	132.44	133.28	134.12	134.96	135.80	136.64	137.48	138.32
+-	11.57	11.58	11.60	11.62	11.64	11.66	11.68	11.69	11.72	11.74
190	139.16	140.00	140.85	141.69	142.53	143.37	144.21	145.05	145.89	146.73
+-	11.76	11.78	11.80	11.83	11.85	11.88	11.90	11.93	11.95	11.98
200	147.57	148.41	149.26	150.10	150.94	151.78	152.62	153.46	154.30	155.14
+-	12.01	12.03	12.06	12.09	12.12	12.15	12.18	12.21	12.24	12.27
210	155.98	156.82	157.67	158.51	159.35	160.19	161.03	161.87	162.71	163.55
+-	12.31	12.34	12.37	12.41	12.44	12.48	12.51	12.55	12.58	12.62

CONTINUED . . .

APPENDIX 10 CONTINUED

1966 TREE 4 CSCN = Y = -21.236 + 0.967TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	36.80	37.77	38.73	39.70	40.67	41.64	42.60	43.57	44.54	45.51
+-	10.32	10.31	10.29	10.27	10.26	10.24	10.22	10.21	10.19	10.17
70	46.47	47.44	48.41	49.37	50.34	51.31	52.28	53.24	54.21	55.18
+-	10.16	10.14	10.13	10.11	10.10	10.08	10.07	10.05	10.04	10.02
80	56.15	57.11	58.08	59.05	60.01	60.98	61.95	62.92	63.88	64.85
+-	10.01	9.99	9.98	9.97	9.95	9.94	9.92	9.91	9.90	9.89
90	65.82	66.79	67.75	68.72	69.69	70.65	71.62	72.59	73.56	74.52
+-	9.87	9.86	9.85	9.84	9.82	9.81	9.80	9.79	9.78	9.77
100	75.49	76.46	77.43	78.39	79.36	80.33	81.29	82.26	83.23	84.20
+-	9.76	9.74	9.73	9.72	9.71	9.70	9.69	9.68	9.67	9.67
110	85.16	86.13	87.10	88.07	89.03	90.00	90.97	91.93	92.90	93.87
+-	9.66	9.65	9.64	9.63	9.62	9.61	9.61	9.60	9.59	9.58
120	94.84	95.80	96.77	97.74	98.71	99.67	100.64	101.61	102.57	103.54
+-	9.57	9.57	9.56	9.55	9.55	9.54	9.53	9.53	9.52	9.52
130	104.51	105.48	106.44	107.41	108.38	109.35	110.31	111.28	112.25	113.21
+-	9.51	9.51	9.50	9.50	9.49	9.49	9.48	9.48	9.48	9.47
140	114.18	115.15	116.12	117.08	118.05	119.02	119.99	120.95	121.92	122.89
+-	9.47	9.46	9.46	9.46	9.46	9.45	9.45	9.45	9.45	9.45
150	123.85	124.82	125.79	126.76	127.72	128.69	129.66	130.63	131.59	132.56
+-	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44
160	133.53	134.49	135.46	136.43	137.40	138.36	139.33	140.30	141.27	142.23
+-	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.45	9.45	9.45
170	143.20	144.17	145.13	146.10	147.07	148.04	149.00	149.97	150.94	151.91
+-	9.45	9.46	9.46	9.46	9.46	9.47	9.47	9.47	9.48	9.48
180	152.87	153.84	154.81	155.77	156.74	157.71	158.68	159.64	160.61	161.58
+-	9.49	9.49	9.50	9.50	9.51	9.51	9.52	9.52	9.53	9.53
190	162.54	163.51	164.48	165.45	166.41	167.38	168.35	169.32	170.28	171.25
+-	9.54	9.55	9.55	9.56	9.57	9.57	9.58	9.59	9.60	9.60
200	172.22	173.18	174.15	175.12	176.09	177.05	178.02	178.99	179.96	180.92
+-	9.61	9.62	9.63	9.64	9.64	9.65	9.66	9.67	9.68	9.69
210	181.89	182.86	183.82	184.79	185.76	186.73	187.69	188.66	189.63	190.60
+-	9.70	9.71	9.72	9.73	9.74	9.75	9.76	9.77	9.79	9.80

CONTINUED . . .

APPENDIX 10 CONTINUED

	1966		TREE 5		CSCN = Y = -17.053 + 0.929TSCN					
TSCN	0	1	2	3	4	5	6	7	8	9
60	38.70	39.63	40.56	41.49	42.41	43.34	44.27	45.20	46.13	47.06
+-	13.26	13.25	13.24	13.23	13.21	13.20	13.19	13.18	13.17	13.15
70	47.99	48.92	49.85	50.78	51.71	52.64	53.57	54.49	55.42	56.35
+-	13.14	13.13	13.12	13.11	13.10	13.09	13.08	13.07	13.06	13.05
80	57.28	58.21	59.14	60.07	61.00	61.93	62.86	63.79	64.72	65.64
+-	13.04	13.03	13.02	13.01	13.00	12.99	12.98	12.97	12.96	12.95
90	66.57	67.50	68.43	69.36	70.29	71.22	72.15	73.08	74.01	74.94
+-	12.94	12.93	12.93	12.92	12.91	12.90	12.89	12.89	12.88	12.87
100	75.87	76.79	77.72	78.65	79.58	80.51	81.44	82.37	83.30	84.23
+-	12.86	12.85	12.85	12.84	12.83	12.83	12.82	12.81	12.81	12.80
110	85.16	86.09	87.02	87.95	88.87	89.80	90.73	91.66	92.59	93.52
+-	12.79	12.79	12.78	12.78	12.77	12.77	12.76	12.75	12.75	12.74
120	94.45	95.38	96.31	97.24	98.17	99.10	100.02	100.95	101.88	102.81
+-	12.74	12.74	12.73	12.73	12.72	12.72	12.71	12.71	12.71	12.70
130	103.74	104.67	105.60	106.53	107.46	108.39	109.32	110.25	111.17	112.10
+-	12.70	12.70	12.69	12.69	12.69	12.68	12.68	12.68	12.68	12.67
140	113.03	113.96	114.89	115.82	116.75	117.68	118.61	119.54	120.47	121.40
+-	12.67	12.67	12.67	12.67	12.66	12.66	12.66	12.66	12.66	12.66
150	122.33	123.25	124.18	125.11	126.04	126.97	127.90	128.83	129.76	130.69
+-	12.66	12.66	12.66	12.66	12.66	12.66	12.66	12.66	12.66	12.66
160	131.62	132.55	133.48	134.40	135.33	136.26	137.19	138.12	139.05	139.98
+-	12.66	12.66	12.66	12.66	12.66	12.66	12.66	12.67	12.67	12.67
170	140.91	141.84	142.77	143.70	144.63	145.55	146.48	147.41	148.34	149.27
+-	12.67	12.67	12.68	12.68	12.68	12.68	12.69	12.69	12.69	12.70
180	150.20	151.13	152.06	152.99	153.92	154.85	155.78	156.71	157.63	158.56
+-	12.70	12.70	12.71	12.71	12.71	12.72	12.72	12.73	12.73	12.73
190	159.49	160.42	161.35	162.28	163.21	164.14	165.07	166.00	166.93	167.86
+-	12.74	12.74	12.75	12.75	12.76	12.77	12.77	12.78	12.78	12.79
200	168.78	169.71	170.64	171.57	172.50	173.43	174.36	175.29	176.22	177.15
+-	12.79	12.80	12.81	12.81	12.82	12.83	12.83	12.84	12.85	12.85
210	178.08	179.01	179.93	180.86	181.79	182.72	183.65	184.58	185.51	186.44
+-	12.86	12.87	12.88	12.88	12.89	12.90	12.91	12.92	12.93	12.93

CONTINUED . . .

APPENDIX 10 CONTINUED

	1966		TREE 6		CSCN = Y = -26.702 + 0.842TSCN					
TSCN	0	1	2	3	4	5	6	7	8	9
60	23.82	24.66	25.50	26.35	27.19	28.03	28.87	29.71	30.56	31.40
+-	20.57	20.46	20.35	20.25	20.14	20.04	19.93	19.83	19.72	19.62
70	32.24	33.08	33.92	34.77	35.61	36.45	37.29	38.13	38.98	39.82
+-	19.52	19.42	19.32	19.23	19.13	19.03	18.94	18.85	18.75	18.66
80	40.66	41.50	42.35	43.19	44.03	44.87	45.71	46.56	47.40	48.24
+-	18.57	18.48	18.40	18.31	18.23	18.14	18.06	17.98	17.90	17.82
90	49.08	49.92	50.77	51.61	52.45	53.29	54.13	54.98	55.82	56.66
+-	17.74	17.67	17.59	17.52	17.45	17.38	17.31	17.24	17.17	17.11
100	57.50	58.34	59.19	60.03	60.87	61.71	62.55	63.40	64.24	65.08
+-	17.04	16.98	16.92	16.86	16.81	16.75	16.70	16.65	16.60	16.55
110	65.92	66.76	67.61	68.45	69.29	70.13	70.97	71.82	72.66	73.50
+-	16.50	16.45	16.41	16.37	16.33	16.29	16.25	16.21	16.18	16.15
120	74.34	75.18	76.03	76.87	77.71	78.55	79.39	80.24	81.08	81.92
+-	16.12	16.09	16.06	16.04	16.02	16.00	15.98	15.96	15.94	15.93
130	82.76	83.61	84.45	85.29	86.13	86.97	87.82	88.66	89.50	90.34
+-	15.92	15.91	15.90	15.89	15.89	15.89	15.89	15.89	15.89	15.90
140	91.18	92.03	92.87	93.71	94.55	95.39	96.24	97.08	97.92	98.76
+-	15.90	15.91	15.92	15.94	15.95	15.97	15.98	16.00	16.03	16.05
150	99.60	100.45	101.29	102.13	102.97	103.81	104.66	105.50	106.34	107.18
+-	16.07	16.10	16.13	16.16	16.19	16.23	16.26	16.30	16.34	16.38
160	108.02	108.87	109.71	110.55	111.39	112.23	113.08	113.92	114.76	115.60
+-	16.43	16.47	16.52	16.56	16.61	16.67	16.72	16.77	16.83	16.89
170	116.44	117.29	118.13	118.97	119.81	120.65	121.50	122.34	123.18	124.02
+-	16.95	17.01	17.07	17.13	17.20	17.26	17.33	17.40	17.47	17.55
180	124.86	125.71	126.55	127.39	128.23	129.08	129.92	130.76	131.60	132.44
+-	17.62	17.69	17.77	17.85	17.93	18.01	18.09	18.17	18.26	18.34
190	133.29	134.13	134.97	135.81	136.65	137.50	138.34	139.18	140.02	140.86
+-	18.43	18.52	18.61	18.70	18.79	18.88	18.98	19.07	19.17	19.26
200	141.71	142.55	143.39	144.23	145.07	145.92	146.76	147.60	148.44	149.28
+-	19.36	19.46	19.56	19.66	19.76	19.87	19.97	20.08	20.18	20.29
210	150.13	150.97	151.81	152.65	153.49	154.34	155.18	156.02	156.86	157.70
+-	20.40	20.50	20.61	20.72	20.84	20.95	21.06	21.17	21.29	21.40

CONTINUED . . .

APPENDIX 10 CONTINUED

1966 TREE 7 CSCN = Y = -7.102 + 0.853TSCN

TSCN		0	1	2	3	4	5	6	7	8	9
60		44.05	44.91	45.76	46.61	47.46	48.32	49.17	50.02	50.87	51.73
	+-	10.66	10.64	10.62	10.60	10.58	10.56	10.54	10.52	10.50	10.48
70		52.58	53.43	54.28	55.14	55.99	56.84	57.69	58.55	59.40	60.25
	+-	10.46	10.44	10.42	10.40	10.38	10.36	10.34	10.33	10.31	10.29
80		61.10	61.96	62.81	63.66	64.51	65.37	66.22	67.07	67.92	68.78
	+-	10.27	10.26	10.24	10.22	10.21	10.19	10.18	10.16	10.14	10.13
90		69.63	70.48	71.34	72.19	73.04	73.89	74.75	75.60	76.45	77.30
	+-	10.12	10.10	10.09	10.07	10.06	10.05	10.03	10.02	10.01	10.00
100		78.16	79.01	79.86	80.71	81.57	82.42	83.27	84.12	84.98	85.83
	+-	9.98	9.97	9.96	9.95	9.94	9.93	9.92	9.91	9.90	9.89
110		86.68	87.53	88.39	89.24	90.09	90.94	91.80	92.65	93.50	94.35
	+-	9.88	9.87	9.86	9.86	9.85	9.84	9.83	9.83	9.82	9.81
120		95.21	96.06	96.91	97.77	98.62	99.47	100.32	101.18	102.03	102.88
	+-	9.81	9.80	9.80	9.79	9.78	9.78	9.78	9.77	9.77	9.76
130		103.73	104.59	105.44	106.29	107.14	108.00	108.85	109.70	110.55	111.41
	+-	9.76	9.76	9.76	9.75	9.75	9.75	9.75	9.75	9.75	9.75
140		112.26	113.11	113.96	114.82	115.67	116.52	117.37	118.23	119.08	119.93
	+-	9.74	9.74	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.76
150		120.78	121.64	122.49	123.34	124.20	125.05	125.90	126.75	127.61	128.46
	+-	9.76	9.76	9.76	9.77	9.77	9.78	9.78	9.79	9.79	9.80
160		129.31	130.16	131.02	131.87	132.72	133.57	134.43	135.28	136.13	136.98
	+-	9.80	9.81	9.81	9.82	9.83	9.83	9.84	9.85	9.86	9.87
170		137.84	138.69	139.54	140.39	141.25	142.10	142.95	143.80	144.66	145.51
	+-	9.87	9.88	9.89	9.90	9.91	9.92	9.93	9.94	9.95	9.96
180		146.36	147.21	148.07	148.92	149.77	150.63	151.48	152.33	153.18	154.04
	+-	9.97	9.99	10.00	10.01	10.02	10.04	10.05	10.06	10.08	10.09
190		154.89	155.74	156.59	157.45	158.30	159.15	160.00	160.86	161.71	162.56
	+-	10.10	10.12	10.13	10.15	10.16	10.18	10.19	10.21	10.23	10.24
200		163.41	164.27	165.12	165.97	166.82	167.68	168.53	169.38	170.23	171.09
	+-	10.26	10.28	10.29	10.31	10.33	10.35	10.36	10.38	10.40	10.42
210		171.94	172.79	173.64	174.50	175.35	176.20	177.06	177.91	178.76	179.61
	+-	10.44	10.46	10.48	10.50	10.52	10.54	10.56	10.58	10.60	10.62

CONTINUED . . .

APPENDIX 10 CONTINUED

1966 TREE 8 CSCN = Y = -17.488 + 0.762TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	28.23	29.00	29.76	30.52	31.28	32.04	32.81	33.57	34.33	35.09
+-	8.72	8.67	8.61	8.56	8.51	8.47	8.42	8.37	8.33	8.28
70	35.85	36.62	37.38	38.14	38.90	39.66	40.43	41.19	41.95	42.71
+-	8.24	8.20	8.16	8.12	8.08	8.04	8.00	7.97	7.94	7.90
80	43.48	44.24	45.00	45.76	46.52	47.29	48.05	48.81	49.57	50.33
+-	7.87	7.84	7.81	7.79	7.76	7.74	7.71	7.69	7.67	7.65
90	51.10	51.86	52.62	53.38	54.14	54.91	55.67	56.43	57.19	57.95
+-	7.64	7.62	7.61	7.59	7.58	7.57	7.56	7.56	7.55	7.55
100	58.72	59.48	60.24	61.00	61.76	62.53	63.29	64.05	64.81	65.57
+-	7.54	7.54	7.54	7.55	7.55	7.55	7.56	7.57	7.58	7.59
110	66.34	67.10	67.86	68.62	69.38	70.15	70.91	71.67	72.43	73.19
+-	7.60	7.61	7.63	7.65	7.66	7.68	7.70	7.73	7.75	7.77
120	73.96	74.72	75.48	76.24	77.00	77.77	78.53	79.29	80.05	80.82
+-	7.80	7.83	7.86	7.89	7.92	7.95	7.99	8.02	8.06	8.10
130	81.58	82.34	83.10	83.86	84.63	85.39	86.15	86.91	87.67	88.44
+-	8.14	8.18	8.22	8.26	8.31	8.35	8.40	8.44	8.49	8.54
140	89.20	89.96	90.72	91.48	92.25	93.01	93.77	94.53	95.29	96.06
+-	8.59	8.64	8.69	8.75	8.80	8.86	8.91	8.97	9.03	9.09
150	96.82	97.58	98.34	99.10	99.87	100.63	101.39	102.15	102.91	103.68
+-	9.15	9.21	9.27	9.33	9.39	9.46	9.52	9.59	9.65	9.72
160	104.44	105.20	105.96	106.72	107.49	108.25	109.01	109.77	110.53	111.30
+-	9.79	9.85	9.92	9.99	10.06	10.13	10.20	10.27	10.35	10.42
170	112.06	112.82	113.58	114.34	115.11	115.87	116.63	117.39	118.16	118.92
+-	10.49	10.57	10.64	10.72	10.79	10.87	10.95	11.02	11.10	11.18
180	119.68	120.44	121.20	121.97	122.73	123.49	124.25	125.01	125.78	126.54
+-	11.26	11.34	11.42	11.50	11.58	11.66	11.74	11.82	11.90	11.98
190	127.30	128.06	128.82	129.59	130.35	131.11	131.87	132.63	133.40	134.16
+-	12.07	12.15	12.23	12.32	12.40	12.48	12.57	12.65	12.74	12.82
200	134.92	135.68	136.44	137.21	137.97	138.73	139.49	140.25	141.02	141.78
+-	12.91	13.00	13.08	13.17	13.26	13.34	13.43	13.52	13.61	13.70
210	142.54	143.30	144.06	144.83	145.59	146.35	147.11	147.87	148.64	149.40
+-	13.79	13.87	13.96	14.05	14.14	14.23	14.32	14.41	14.50	14.59

CONTINUED . . .

APPENDIX 10 CONTINUED

1966 TREE 9 CSCN = Y = -13.944 + 0.819TSCN

TSCN		0	1	2	3	4	5	6	7	8	9
60		35.20	36.02	36.84	37.66	38.48	39.30	40.12	40.93	41.75	42.57
	+-	9.34	9.29	9.25	9.20	9.16	9.11	9.07	9.03	8.99	8.94
70		43.39	44.21	45.03	45.85	46.67	47.49	48.31	49.13	49.94	50.76
	+-	8.90	8.86	8.82	8.78	8.74	8.70	8.67	8.63	8.59	8.55
80		51.58	52.40	53.22	54.04	54.86	55.68	56.50	57.32	58.14	58.95
	+-	8.52	8.48	8.45	8.41	8.38	8.34	8.31	8.28	8.25	8.22
90		59.77	60.59	61.41	62.23	63.05	63.87	64.69	65.51	66.33	67.15
	+-	8.19	8.16	8.13	8.10	8.07	8.04	8.01	7.99	7.96	7.94
100		67.96	68.78	69.60	70.42	71.24	72.06	72.88	73.70	74.52	75.34
	+-	7.91	7.89	7.86	7.84	7.82	7.80	7.78	7.76	7.74	7.72
110		76.16	76.97	77.79	78.61	79.43	80.25	81.07	81.89	82.71	83.53
	+-	7.70	7.69	7.67	7.65	7.64	7.62	7.61	7.60	7.59	7.57
120		84.35	85.16	85.98	86.80	87.62	88.44	89.26	90.08	90.90	91.72
	+-	7.56	7.55	7.55	7.54	7.53	7.52	7.52	7.51	7.51	7.50
130		92.54	93.36	94.17	94.99	95.81	96.63	97.45	98.27	99.09	99.91
	+-	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.51
140		100.73	101.55	102.37	103.18	104.00	104.82	105.64	106.46	107.28	108.10
	+-	7.51	7.52	7.53	7.53	7.54	7.55	7.56	7.57	7.58	7.59
150		108.92	109.74	110.56	111.38	112.19	113.01	113.83	114.65	115.47	116.29
	+-	7.60	7.62	7.63	7.64	7.66	7.68	7.69	7.71	7.73	7.75
160		117.11	117.93	118.75	119.57	120.39	121.20	122.02	122.84	123.66	124.48
	+-	7.77	7.79	7.81	7.83	7.85	7.87	7.90	7.92	7.95	7.97
170		125.30	126.12	126.94	127.76	128.58	129.40	130.21	131.03	131.85	132.67
	+-	8.00	8.02	8.05	8.08	8.11	8.14	8.17	8.20	8.23	8.26
180		133.49	134.31	135.13	135.95	136.77	137.59	138.41	139.22	140.04	140.86
	+-	8.29	8.32	8.36	8.39	8.43	8.46	8.50	8.53	8.57	8.61
190		141.68	142.50	143.32	144.14	144.96	145.78	146.60	147.42	148.23	149.05
	+-	8.64	8.68	8.72	8.76	8.80	8.84	8.88	8.92	8.96	9.00
200		149.87	150.69	151.51	152.33	153.15	153.97	154.79	155.61	156.42	157.24
	+-	9.04	9.09	9.13	9.17	9.22	9.26	9.31	9.35	9.40	9.44
210		158.06	158.88	159.70	160.52	161.34	162.16	162.98	163.80	164.62	165.43
	+-	9.49	9.54	9.58	9.63	9.68	9.73	9.78	9.82	9.87	9.92

CONTINUED . . .

APPENDIX 10 CONTINUED

	1966		TREE 10		CSCN = Y = -14.686 + 0.800TSCN					
TSCN	0	1	2	3	4	5	6	7	8	9
60	33.32	34.12	34.92	35.72	36.52	37.32	38.12	38.92	39.72	40.52
+-	10.65	10.59	10.53	10.47	10.42	10.36	10.30	10.25	10.20	10.14
70	41.32	42.12	42.93	43.73	44.53	45.33	46.13	46.93	47.73	48.53
+-	10.09	10.04	9.99	9.94	9.89	9.84	9.79	9.74	9.70	9.65
80	49.33	50.13	50.93	51.73	52.53	53.33	54.13	54.93	55.73	56.53
+-	9.61	9.57	9.52	9.48	9.44	9.40	9.36	9.33	9.29	9.26
90	57.33	58.13	58.93	59.73	60.53	61.33	62.13	62.93	63.73	64.53
+-	9.22	9.19	9.15	9.12	9.09	9.06	9.04	9.01	8.98	8.96
100	65.33	66.13	66.93	67.73	68.53	69.33	70.13	70.93	71.73	72.53
+-	8.93	8.91	8.89	8.87	8.85	8.83	8.81	8.80	8.78	8.77
110	73.33	74.13	74.93	75.73	76.53	77.33	78.13	78.93	79.73	80.53
+-	8.76	8.75	8.74	8.73	8.72	8.72	8.71	8.71	8.70	8.70
120	81.33	82.13	82.93	83.73	84.53	85.33	86.13	86.93	87.73	88.53
+-	8.70	8.70	8.71	8.71	8.71	8.72	8.73	8.74	8.75	8.76
130	89.33	90.13	90.93	91.73	92.54	93.34	94.14	94.94	95.74	96.54
+-	8.77	8.78	8.80	8.81	8.83	8.85	8.87	8.89	8.91	8.93
140	97.34	98.14	98.94	99.74	100.54	101.34	102.14	102.94	103.74	104.54
+-	8.95	8.98	9.00	9.03	9.06	9.09	9.12	9.15	9.18	9.21
150	105.34	106.14	106.94	107.74	108.54	109.34	110.14	110.94	111.74	112.54
+-	9.25	9.28	9.32	9.36	9.40	9.44	9.48	9.52	9.56	9.60
160	113.34	114.14	114.94	115.74	116.54	117.34	118.14	118.94	119.74	120.54
+-	9.65	9.69	9.74	9.78	9.83	9.88	9.93	9.98	10.03	10.08
170	121.34	122.14	122.94	123.74	124.54	125.34	126.14	126.94	127.74	128.54
+-	10.13	10.19	10.24	10.30	10.35	10.41	10.46	10.52	10.58	10.64
180	129.34	130.14	130.94	131.74	132.54	133.34	134.14	134.94	135.74	136.54
+-	10.70	10.76	10.82	10.88	10.94	11.00	11.07	11.13	11.20	11.26
190	137.34	138.14	138.94	139.74	140.54	141.34	142.14	142.95	143.75	144.55
+-	11.33	11.39	11.46	11.53	11.59	11.66	11.73	11.80	11.87	11.94
200	145.35	146.15	146.95	147.75	148.55	149.35	150.15	150.95	151.75	152.55
+-	12.01	12.08	12.15	12.23	12.30	12.37	12.45	12.52	12.59	12.67
210	153.35	154.15	154.95	155.75	156.55	157.35	158.15	158.95	159.75	160.55
+-	12.74	12.82	12.89	12.97	13.05	13.12	13.20	13.28	13.36	13.44

CONTINUED . . .

APPENDIX 10 CONTINUED

1966 TREE 11 CSCN = Y = -41.096 + 0.986TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	18.06	19.04	20.03	21.01	22.00	22.98	23.97	24.96	25.94	26.93
+-	12.45	12.39	12.33	12.27	12.20	12.14	12.08	12.02	11.97	11.91
70	27.91	28.90	29.89	30.87	31.86	32.84	33.83	34.81	35.80	36.79
+-	11.85	11.79	11.74	11.68	11.63	11.58	11.52	11.47	11.42	11.37
80	37.77	38.76	39.74	40.73	41.72	42.70	43.69	44.67	45.66	46.65
+-	11.32	11.27	11.23	11.18	11.13	11.09	11.05	11.00	10.96	10.92
90	47.63	48.62	49.60	50.59	51.57	52.56	53.55	54.53	55.52	56.50
+-	10.88	10.84	10.80	10.77	10.73	10.70	10.66	10.63	10.60	10.57
100	57.49	58.48	59.46	60.45	61.43	62.42	63.40	64.39	65.38	66.36
+-	10.54	10.51	10.48	10.46	10.43	10.41	10.38	10.36	10.34	10.32
110	67.35	68.33	69.32	70.31	71.29	72.28	73.26	74.25	75.24	76.22
+-	10.30	10.28	10.27	10.25	10.24	10.23	10.22	10.21	10.20	10.19
120	77.21	78.19	79.18	80.16	81.15	82.14	83.12	84.11	85.09	86.08
+-	10.18	10.18	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.18
130	87.07	88.05	89.04	90.02	91.01	91.99	92.98	93.97	94.95	95.94
+-	10.18	10.19	10.19	10.20	10.21	10.23	10.24	10.25	10.27	10.28
140	96.92	97.91	98.90	99.88	100.87	101.85	102.84	103.83	104.81	105.80
+-	10.30	10.32	10.34	10.36	10.38	10.40	10.43	10.45	10.48	10.50
150	106.78	107.77	108.75	109.74	110.73	111.71	112.70	113.68	114.67	115.66
+-	10.53	10.56	10.59	10.62	10.66	10.69	10.73	10.76	10.80	10.84
160	116.64	117.63	118.61	119.60	120.58	121.57	122.56	123.54	124.53	125.51
+-	10.87	10.91	10.95	11.00	11.04	11.08	11.13	11.17	11.22	11.27
170	126.50	127.49	128.47	129.46	130.44	131.43	132.42	133.40	134.39	135.37
+-	11.31	11.36	11.41	11.46	11.52	11.57	11.62	11.67	11.73	11.78
180	136.36	137.34	138.33	139.32	140.30	141.29	142.27	143.26	144.25	145.23
+-	11.84	11.90	11.96	12.01	12.07	12.13	12.19	12.26	12.32	12.38
190	146.22	147.20	148.19	149.17	150.16	151.15	152.13	153.12	154.10	155.09
+-	12.44	12.51	12.57	12.64	12.70	12.77	12.84	12.91	12.97	13.04
200	156.08	157.06	158.05	159.03	160.02	161.00	161.99	162.98	163.96	164.95
+-	13.11	13.18	13.25	13.33	13.40	13.47	13.54	13.62	13.69	13.76
210	165.93	166.92	167.91	168.89	169.88	170.86	171.85	172.84	173.82	174.81
+-	13.84	13.91	13.99	14.07	14.14	14.22	14.30	14.37	14.45	14.53

CONTINUED . . .

APPENDIX 10 CONTINUED

	1966	TREE 12		CSCN = Y = -11.415 + 0.888TSCN						
TSCN	0	1	2	3	4	5	6	7	8	9
60	41.84	42.73	43.61	44.50	45.39	46.28	47.16	48.05	48.94	49.83
+-	10.60	10.58	10.57	10.56	10.55	10.54	10.53	10.52	10.51	10.50
70	50.71	51.60	52.49	53.38	54.26	55.15	56.04	56.93	57.81	58.70
+-	10.49	10.48	10.47	10.46	10.45	10.44	10.43	10.42	10.41	10.40
80	59.59	60.48	61.36	62.25	63.14	64.03	64.92	65.80	66.69	67.58
+-	10.39	10.39	10.38	10.37	10.36	10.36	10.35	10.34	10.33	10.33
90	68.47	69.35	70.24	71.13	72.02	72.90	73.79	74.68	75.57	76.45
+-	10.32	10.32	10.31	10.30	10.30	10.29	10.29	10.28	10.28	10.27
100	77.34	78.23	79.12	80.00	80.89	81.78	82.67	83.55	84.44	85.33
+-	10.27	10.26	10.26	10.26	10.25	10.25	10.24	10.24	10.24	10.24
110	86.22	87.10	87.99	88.88	89.77	90.65	91.54	92.43	93.32	94.20
+-	10.23	10.23	10.23	10.23	10.23	10.22	10.22	10.22	10.22	10.22
120	95.09	95.98	96.87	97.75	98.64	99.53	100.42	101.31	102.19	103.08
+-	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22
130	103.97	104.86	105.74	106.63	107.52	108.41	109.29	110.18	111.07	111.96
+-	10.22	10.23	10.23	10.23	10.23	10.24	10.24	10.24	10.24	10.25
140	112.84	113.73	114.62	115.51	116.39	117.28	118.17	119.06	119.94	120.83
+-	10.25	10.25	10.26	10.26	10.27	10.27	10.27	10.28	10.28	10.29
150	121.72	122.61	123.49	124.38	125.27	126.16	127.04	127.93	128.82	129.71
+-	10.30	10.30	10.31	10.31	10.32	10.32	10.33	10.34	10.35	10.35
160	130.59	131.48	132.37	133.26	134.14	135.03	135.92	136.81	137.69	138.58
+-	10.36	10.37	10.37	10.38	10.39	10.40	10.41	10.42	10.42	10.43
170	139.47	140.36	141.25	142.13	143.02	143.91	144.80	145.68	146.57	147.46
+-	10.44	10.45	10.46	10.47	10.48	10.49	10.50	10.51	10.52	10.53
180	148.35	149.23	150.12	151.01	151.90	152.78	153.67	154.56	155.45	156.33
+-	10.55	10.56	10.57	10.58	10.59	10.60	10.61	10.63	10.64	10.65
190	157.22	158.11	159.00	159.88	160.77	161.66	162.55	163.43	164.32	165.21
+-	10.67	10.68	10.69	10.70	10.72	10.73	10.75	10.76	10.77	10.79
200	166.10	166.98	167.87	168.76	169.65	170.53	171.42	172.31	173.20	174.08
+-	10.80	10.82	10.83	10.85	10.86	10.88	10.89	10.91	10.92	10.94
210	174.97	175.86	176.75	177.64	178.52	179.41	180.30	181.19	182.07	182.96
+-	10.96	10.97	10.99	11.01	11.02	11.04	11.06	11.07	11.09	11.11

CONTINUED . . .

APPENDIX 10 CONTINUED

1968 TREE 1 CSCN = Y = -18.670 + 0.950TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	38.32	39.27	40.22	41.17	42.12	43.07	44.02	44.97	45.92	46.87
+-	8.54	8.51	8.48	8.46	8.43	8.40	8.38	8.35	8.32	8.30
70	47.82	48.77	49.72	50.67	51.61	52.56	53.51	54.46	55.41	56.36
+-	8.27	8.25	8.22	8.20	8.17	8.15	8.13	8.10	8.08	8.05
80	57.31	58.26	59.21	60.16	61.11	62.06	63.01	63.96	64.91	65.86
+-	8.03	8.01	7.98	7.96	7.94	7.92	7.90	7.87	7.85	7.83
90	66.81	67.76	68.71	69.66	70.61	71.56	72.51	73.46	74.41	75.36
+-	7.81	7.79	7.77	7.75	7.73	7.71	7.69	7.67	7.65	7.63
100	76.31	77.26	78.21	79.16	80.11	81.06	82.01	82.96	83.91	84.86
+-	7.61	7.59	7.57	7.56	7.54	7.52	7.50	7.49	7.47	7.45
110	85.81	86.76	87.71	88.66	89.61	90.56	91.51	92.46	93.41	94.36
+-	7.44	7.42	7.41	7.39	7.38	7.36	7.35	7.33	7.32	7.31
120	95.31	96.26	97.21	98.16	99.10	100.05	101.00	101.95	102.90	103.85
+-	7.29	7.28	7.27	7.25	7.24	7.23	7.22	7.21	7.20	7.19
130	104.80	105.75	106.70	107.65	108.60	109.55	110.50	111.45	112.40	113.35
+-	7.17	7.16	7.15	7.15	7.14	7.13	7.12	7.11	7.10	7.09
140	114.30	115.25	116.20	117.15	118.10	119.05	120.00	120.95	121.90	122.85
+-	7.09	7.08	7.07	7.07	7.06	7.05	7.05	7.04	7.04	7.03
150	123.80	124.75	125.70	126.65	127.60	128.55	129.50	130.45	131.40	132.35
+-	7.03	7.03	7.02	7.02	7.02	7.01	7.01	7.01	7.01	7.01
160	133.30	134.25	135.20	136.15	137.10	138.05	139.00	139.95	140.90	141.85
+-	7.01	7.01	7.00	7.00	7.01	7.01	7.01	7.01	7.01	7.01
170	142.80	143.75	144.70	145.65	146.59	147.54	148.49	149.44	150.39	151.34
+-	7.01	7.02	7.02	7.02	7.03	7.03	7.03	7.04	7.04	7.05
180	152.29	153.24	154.19	155.14	156.09	157.04	157.99	158.94	159.89	160.84
+-	7.05	7.06	7.06	7.07	7.08	7.08	7.09	7.10	7.11	7.12
190	161.79	162.74	163.69	164.64	165.59	166.54	167.49	168.44	169.39	170.34
+-	7.12	7.13	7.14	7.15	7.16	7.17	7.18	7.19	7.20	7.21
200	171.29	172.24	173.19	174.14	175.09	176.04	176.99	177.94	178.89	179.84
+-	7.23	7.24	7.25	7.26	7.27	7.29	7.30	7.31	7.33	7.34
210	180.79	181.74	182.69	183.64	184.59	185.54	186.49	187.44	188.39	189.34
+-	7.36	7.37	7.39	7.40	7.42	7.43	7.45	7.47	7.48	7.50

CONTINUED . . .

APPENDIX 10 CONTINUED

1968 TREE 2 CSCN = Y = -50.060 + 1.120TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	17.17	18.29	19.41	20.53	21.65	22.77	23.89	25.01	26.13	27.25
+-	16.68	16.66	16.63	16.60	16.58	16.55	16.53	16.50	16.48	16.45
70	28.37	29.49	30.61	31.73	32.85	33.97	35.09	36.21	37.33	38.45
+-	16.43	16.41	16.38	16.36	16.34	16.32	16.30	16.28	16.26	16.24
80	39.57	40.69	41.81	42.94	44.06	45.18	46.30	47.42	48.54	49.66
+-	16.22	16.20	16.19	16.17	16.15	16.14	16.12	16.11	16.09	16.08
90	50.78	51.90	53.02	54.14	55.26	56.38	57.50	58.62	59.74	60.86
+-	16.06	16.05	16.04	16.03	16.02	16.00	15.99	15.98	15.98	15.97
100	61.98	63.10	64.22	65.34	66.46	67.58	68.71	69.83	70.95	72.07
+-	15.96	15.95	15.94	15.94	15.93	15.93	15.92	15.92	15.91	15.91
110	73.19	74.31	75.43	76.55	77.67	78.79	79.91	81.03	82.15	83.27
+-	15.91	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90
120	84.39	85.51	86.63	87.75	88.87	89.99	91.11	92.23	93.35	94.47
+-	15.90	15.91	15.91	15.91	15.92	15.92	15.93	15.94	15.94	15.95
130	95.60	96.72	97.84	98.96	100.08	101.20	102.32	103.44	104.56	105.68
+-	15.96	15.97	15.97	15.98	15.99	16.00	16.01	16.02	16.04	16.05
140	106.80	107.92	109.04	110.16	111.28	112.40	113.52	114.64	115.76	116.88
+-	16.06	16.08	16.09	16.10	16.12	16.13	16.15	16.17	16.18	16.20
150	118.00	119.12	120.24	121.37	122.49	123.61	124.73	125.85	126.97	128.09
+-	16.22	16.24	16.26	16.27	16.29	16.31	16.34	16.36	16.38	16.40
160	129.21	130.33	131.45	132.57	133.69	134.81	135.93	137.05	138.17	139.29
+-	16.42	16.45	16.47	16.50	16.52	16.55	16.57	16.60	16.62	16.65
170	140.41	141.53	142.65	143.77	144.89	146.01	147.14	148.26	149.38	150.50
+-	16.68	16.71	16.73	16.76	16.79	16.82	16.85	16.88	16.91	16.95
180	151.62	152.74	153.86	154.98	156.10	157.22	158.34	159.46	160.58	161.70
+-	16.98	17.01	17.04	17.08	17.11	17.15	17.18	17.21	17.25	17.29
190	162.82	163.94	165.06	166.18	167.30	168.42	169.54	170.66	171.78	172.91
+-	17.32	17.36	17.40	17.43	17.47	17.51	17.55	17.59	17.63	17.67
200	174.03	175.15	176.27	177.39	178.51	179.63	180.75	181.87	182.99	184.11
+-	17.71	17.75	17.79	17.83	17.87	17.91	17.96	18.00	18.04	18.09
210	185.23	186.35	187.47	188.59	189.71	190.83	191.95	193.07	194.19	195.31
+-	18.13	18.17	18.22	18.26	18.31	18.36	18.40	18.45	18.49	18.54

CONTINUED . . .

APPENDIX 10 CONTINUED

1968 TREE 4 CSCN = Y = -34.128 + 0.975TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	24.37	25.35	26.32	27.30	28.27	29.25	30.22	31.20	32.17	33.15
+-	25.78	25.67	25.56	25.45	25.34	25.23	25.12	25.01	24.90	24.79
70	34.12	35.09	36.07	37.04	38.02	38.99	39.97	40.94	41.92	42.89
+-	24.69	24.58	24.48	24.37	24.27	24.17	24.07	23.97	23.87	23.77
80	43.87	44.84	45.82	46.79	47.77	48.74	49.72	50.69	51.67	52.64
+-	23.67	23.57	23.48	23.38	23.29	23.19	23.10	23.01	22.92	22.83
90	53.62	54.59	55.57	56.54	57.52	58.49	59.47	60.44	61.42	62.39
+-	22.74	22.65	22.56	22.48	22.39	22.31	22.23	22.15	22.07	21.99
100	63.37	64.34	65.32	66.29	67.27	68.24	69.22	70.19	71.17	72.14
+-	21.91	21.83	21.75	21.68	21.60	21.53	21.46	21.39	21.32	21.25
110	73.12	74.09	75.07	76.04	77.02	77.99	78.97	79.94	80.92	81.89
+-	21.18	21.12	21.05	20.99	20.93	20.87	20.81	20.75	20.69	20.64
120	82.87	83.84	84.82	85.79	86.77	87.74	88.72	89.69	90.67	91.64
+-	20.58	20.53	20.48	20.43	20.38	20.33	20.29	20.24	20.20	20.16
130	92.62	93.59	94.57	95.54	96.52	97.49	98.47	99.44	100.42	101.39
+-	20.11	20.08	20.04	20.00	19.97	19.93	19.90	19.87	19.84	19.81
140	102.37	103.34	104.32	105.29	106.27	107.24	108.22	109.19	110.17	111.14
+-	19.79	19.76	19.74	19.72	19.70	19.68	19.66	19.65	19.63	19.62
150	112.12	113.09	114.07	115.04	116.02	116.99	117.97	118.94	119.92	120.89
+-	19.61	19.60	19.59	19.59	19.58	19.58	19.58	19.58	19.58	19.58
160	121.87	122.84	123.82	124.79	125.77	126.74	127.72	128.69	129.67	130.64
+-	19.58	19.59	19.60	19.61	19.62	19.63	19.64	19.66	19.67	19.69
170	131.62	132.59	133.57	134.54	135.52	136.49	137.47	138.44	139.42	140.39
+-	19.71	19.73	19.76	19.78	19.81	19.83	19.86	19.89	19.92	19.96
180	141.37	142.34	143.32	144.29	145.27	146.24	147.22	148.19	149.17	150.14
+-	19.99	20.03	20.06	20.10	20.14	20.18	20.23	20.27	20.32	20.36
190	151.12	152.09	153.07	154.04	155.02	155.99	156.97	157.94	158.92	159.89
+-	20.41	20.46	20.51	20.57	20.62	20.68	20.73	20.79	20.85	20.91
200	160.87	161.84	162.82	163.79	164.77	165.74	166.72	167.69	168.67	169.64
+-	20.97	21.03	21.10	21.16	21.23	21.30	21.37	21.44	21.51	21.58
210	170.62	171.59	172.57	173.54	174.52	175.49	176.47	177.44	178.42	179.39
+-	21.65	21.73	21.81	21.88	21.96	22.04	22.12	22.20	22.28	22.37

CONTINUED . . .

APPENDIX 10 CONTINUED

1968 TREE 5 CSCN = Y = 19.887 + 0.672TSCN

TSCN		0	1	2	3	4	5	6	7	8	9
60		60.22	60.89	61.56	62.23	62.91	63.58	64.25	64.92	65.59	66.27
	+-	31.73	31.51	31.29	31.08	30.86	30.65	30.43	30.22	30.00	29.79
70		66.94	67.61	68.28	68.96	69.63	70.30	70.97	71.64	72.32	72.99
	+-	29.58	29.37	29.16	28.95	28.74	28.53	28.32	28.12	27.91	27.71
80		73.66	74.33	75.00	75.68	76.35	77.02	77.69	78.37	79.04	79.71
	+-	27.50	27.30	27.10	26.90	26.70	26.50	26.30	26.10	25.90	25.71
90		80.38	81.05	81.73	82.40	83.07	83.74	84.41	85.09	85.76	86.43
	+-	25.51	25.32	25.13	24.94	24.75	24.56	24.37	24.19	24.00	23.82
100		87.10	87.78	88.45	89.12	89.79	90.46	91.14	91.81	92.48	93.15
	+-	23.64	23.46	23.28	23.10	22.92	22.75	22.57	22.40	22.23	22.06
110		93.83	94.50	95.17	95.84	96.51	97.19	97.86	98.53	99.20	99.87
	+-	21.90	21.73	21.57	21.41	21.25	21.09	20.94	20.78	20.63	20.48
120		100.55	101.22	101.89	102.56	103.24	103.91	104.58	105.25	105.92	106.60
	+-	20.33	20.19	20.05	19.91	19.77	19.63	19.50	19.37	19.24	19.11
130		107.27	107.94	108.61	109.29	109.96	110.63	111.30	111.97	112.65	113.32
	+-	18.99	18.87	18.75	18.64	18.52	18.41	18.31	18.21	18.10	18.01
140		113.99	114.66	115.33	116.01	116.68	117.35	118.02	118.70	119.37	120.04
	+-	17.91	17.82	17.73	17.65	17.57	17.49	17.42	17.35	17.28	17.22
150		120.71	121.38	122.06	122.73	123.40	124.07	124.75	125.42	126.09	126.76
	+-	17.16	17.10	17.05	17.00	16.95	16.91	16.87	16.84	16.81	16.78
160		127.43	128.11	128.78	129.45	130.12	130.79	131.47	132.14	132.81	133.48
	+-	16.76	16.74	16.73	16.72	16.71	16.71	16.71	16.71	16.72	16.73
170		134.16	134.83	135.50	136.17	136.84	137.52	138.19	138.86	139.53	140.21
	+-	16.75	16.77	16.80	16.82	16.86	16.89	16.93	16.98	17.02	17.08
180		140.88	141.55	142.22	142.89	143.57	144.24	144.91	145.58	146.25	146.93
	+-	17.13	17.19	17.25	17.32	17.39	17.46	17.53	17.61	17.70	17.78
190		147.60	148.27	148.94	149.62	150.29	150.96	151.63	152.30	152.98	153.65
	+-	17.87	17.97	18.06	18.16	18.26	18.37	18.48	18.59	18.70	18.82
200		154.32	154.99	155.67	156.34	157.01	157.68	158.35	159.03	159.70	160.37
	+-	18.94	19.06	19.18	19.31	19.44	19.57	19.71	19.84	19.98	20.13
210		161.04	161.71	162.39	163.06	163.73	164.40	165.08	165.75	166.42	167.09
	+-	20.27	20.42	20.56	20.71	20.87	21.02	21.18	21.34	21.50	21.66

CONTINUED . . .

APPENDIX 10 CONTINUED

	1968	TREE 6		CSCN = Y = -35.637 + 0.981TSCN						
TSCN	0	1	2	3	4	5	6	7	8	9
60	23.22	24.20	25.18	26.16	27.14	28.12	29.10	30.08	31.06	32.04
+-	52.80	52.28	51.76	51.25	50.73	50.22	49.70	49.19	48.68	48.17
70	33.03	34.01	34.99	35.97	36.95	37.93	38.91	39.89	40.87	41.85
+-	47.66	47.15	46.65	46.14	45.64	45.14	44.64	44.14	43.64	43.15
80	42.83	43.82	44.80	45.78	46.76	47.74	48.72	49.70	50.68	51.66
+-	42.66	42.16	41.68	41.19	40.71	40.22	39.74	39.27	38.79	38.32
90	52.64	53.62	54.60	55.59	56.57	57.55	58.53	59.51	60.49	61.47
+-	37.85	37.38	36.92	36.46	36.00	35.54	35.09	34.65	34.20	33.76
100	62.45	63.43	64.41	65.39	66.38	67.36	68.34	69.32	70.30	71.28
+-	33.32	32.89	32.46	32.04	31.62	31.21	30.80	30.39	29.99	29.60
110	72.26	73.24	74.22	75.20	76.18	77.17	78.15	79.13	80.11	81.09
+-	29.21	28.83	28.46	28.09	27.73	27.37	27.02	26.68	26.35	26.03
120	82.07	83.05	84.03	85.01	85.99	86.97	87.96	88.94	89.92	90.90
+-	25.71	25.41	25.11	24.82	24.55	24.28	24.02	23.78	23.54	23.32
130	91.88	92.86	93.84	94.82	95.80	96.78	97.76	98.75	99.73	100.71
+-	23.11	22.91	22.72	22.55	22.39	22.24	22.11	21.99	21.88	21.79
140	101.69	102.67	103.65	104.63	105.61	106.59	107.57	108.55	109.53	110.52
+-	21.72	21.66	21.61	21.58	21.56	21.56	21.57	21.60	21.65	21.70
150	111.50	112.48	113.46	114.44	115.42	116.40	117.38	118.36	119.34	120.32
+-	21.78	21.87	21.97	22.08	22.21	22.36	22.52	22.69	22.87	23.07
160	121.31	122.29	123.27	124.25	125.23	126.21	127.19	128.17	129.15	130.13
+-	23.28	23.50	23.73	23.97	24.23	24.49	24.77	25.05	25.35	25.65
170	131.11	132.10	133.08	134.06	135.04	136.02	137.00	137.98	138.96	139.94
+-	25.97	26.29	26.62	26.96	27.30	27.65	28.02	28.38	28.76	29.14
180	140.92	141.90	142.89	143.87	144.85	145.83	146.81	147.79	148.77	149.75
+-	29.52	29.91	30.31	30.72	31.12	31.54	31.96	32.38	32.81	33.24
190	150.73	151.71	152.69	153.67	154.66	155.64	156.62	157.60	158.58	159.56
+-	33.67	34.11	34.56	35.00	35.45	35.91	36.37	36.83	37.29	37.76
200	160.54	161.52	162.50	163.48	164.46	165.45	166.43	167.41	168.39	169.37
+-	38.22	38.70	39.17	39.65	40.13	40.61	41.09	41.58	42.07	42.56
210	170.35	171.33	172.31	173.29	174.27	175.25	176.24	177.22	178.20	179.18
+-	43.05	43.54	44.04	44.54	45.04	45.54	46.04	46.54	47.05	47.56

CONTINUED . . .

APPENDIX 10 CONTINUED

1968 TREE 7 CSCN = Y = -23.766 + 0.974TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	34.69	35.66	36.64	37.61	38.59	39.56	40.54	41.51	42.48	43.46
+-	19.08	18.94	18.80	18.66	18.53	18.39	18.25	18.12	17.99	17.85
70	44.43	45.41	46.38	47.36	48.33	49.30	50.28	51.25	52.23	53.20
+-	17.72	17.59	17.46	17.33	17.20	17.08	16.95	16.83	16.70	16.58
80	54.18	55.15	56.12	57.10	58.07	59.05	60.02	60.99	61.97	62.94
+-	16.46	16.34	16.22	16.10	15.99	15.87	15.76	15.65	15.53	15.43
90	63.92	64.89	65.87	66.84	67.81	68.79	69.76	70.74	71.71	72.69
+-	15.32	15.21	15.11	15.00	14.90	14.80	14.70	14.61	14.51	14.42
100	73.66	74.63	75.61	76.58	77.56	78.53	79.51	80.48	81.45	82.43
+-	14.33	14.24	14.15	14.06	13.98	13.90	13.82	13.74	13.66	13.59
110	83.40	84.38	85.35	86.33	87.30	88.27	89.25	90.22	91.20	92.17
+-	13.52	13.45	13.38	13.32	13.26	13.20	13.14	13.08	13.03	12.98
120	93.15	94.12	95.09	96.07	97.04	98.02	98.99	99.97	100.94	101.91
+-	12.93	12.88	12.84	12.80	12.76	12.73	12.69	12.66	12.64	12.61
130	102.89	103.86	104.84	105.81	106.79	107.76	108.73	109.71	110.68	111.66
+-	12.59	12.57	12.55	12.54	12.53	12.52	12.51	12.51	12.51	12.51
140	112.63	113.60	114.58	115.55	116.53	117.50	118.48	119.45	120.42	121.40
+-	12.52	12.53	12.54	12.55	12.57	12.58	12.61	12.63	12.66	12.69
150	122.37	123.35	124.32	125.30	126.27	127.24	128.22	129.19	130.17	131.14
+-	12.72	12.75	12.79	12.83	12.87	12.92	12.97	13.02	13.07	13.12
160	132.12	133.09	134.06	135.04	136.01	136.99	137.96	138.94	139.91	140.88
+-	13.18	13.24	13.30	13.37	13.43	13.50	13.57	13.65	13.72	13.80
170	141.86	142.83	143.81	144.78	145.76	146.73	147.70	148.68	149.65	150.63
+-	13.88	13.96	14.04	14.13	14.22	14.31	14.40	14.49	14.58	14.68
180	151.60	152.58	153.55	154.52	155.50	156.47	157.45	158.42	159.40	160.37
+-	14.78	14.88	14.98	15.08	15.19	15.29	15.40	15.51	15.62	15.73
190	161.34	162.32	163.29	164.27	165.24	166.21	167.19	168.16	169.14	170.11
+-	15.84	15.96	16.08	16.19	16.31	16.43	16.55	16.67	16.80	16.92
200	171.09	172.06	173.03	174.01	174.98	175.96	176.93	177.91	178.88	179.85
+-	17.05	17.17	17.30	17.43	17.56	17.69	17.82	17.96	18.09	18.22
210	180.83	181.80	182.78	183.75	184.73	185.70	186.67	187.65	188.62	189.60
+-	18.36	18.50	18.63	18.77	18.91	19.05	19.19	19.33	19.47	19.61

CONTINUED . . .

APPENDIX 10 CONTINUED

1968 TREE 8 CSCN = Y = -34.272 + 0.978TSCN

TSCN	0	1	2	3	4	5	6	7	8	9
60	24.42	25.39	26.37	27.35	28.33	29.31	30.29	31.26	32.24	33.22
+-	14.97	14.76	14.55	14.34	14.13	13.93	13.73	13.53	13.34	13.15
70	34.20	35.18	36.15	37.13	38.11	39.09	40.07	41.04	42.02	43.00
+-	12.96	12.77	12.59	12.41	12.23	12.06	11.89	11.73	11.57	11.41
80	43.98	44.96	45.94	46.91	47.89	48.87	49.85	50.83	51.80	52.78
+-	11.26	11.11	10.97	10.84	10.71	10.58	10.46	10.35	10.24	10.14
90	53.76	54.74	55.72	56.70	57.67	58.65	59.63	60.61	61.59	62.56
+-	10.05	9.96	9.88	9.81	9.74	9.69	9.63	9.59	9.56	9.53
100	63.54	64.52	65.50	66.48	67.45	68.43	69.41	70.39	71.37	72.35
+-	9.51	9.50	9.49	9.50	9.51	9.53	9.56	9.60	9.64	9.69
110	73.32	74.30	75.28	76.26	77.24	78.21	79.19	80.17	81.15	82.13
+-	9.75	9.82	9.89	9.97	10.06	10.15	10.26	10.36	10.48	10.60
120	83.10	84.08	85.06	86.04	87.02	88.00	88.97	89.95	90.93	91.91
+-	10.72	10.85	10.99	11.13	11.28	11.43	11.58	11.75	11.91	12.08
130	92.89	93.86	94.84	95.82	96.80	97.78	98.76	99.73	100.71	101.69
+-	12.25	12.43	12.61	12.79	12.98	13.17	13.36	13.56	13.75	13.95
140	102.67	103.65	104.62	105.60	106.58	107.56	108.54	109.51	110.49	111.47
+-	14.16	14.36	14.57	14.78	15.00	15.21	15.43	15.64	15.87	16.09
150	112.45	113.43	114.41	115.38	116.36	117.34	118.32	119.30	120.27	121.25
+-	16.31	16.54	16.76	16.99	17.22	17.45	17.68	17.92	18.15	18.39
160	122.23	123.21	124.19	125.17	126.14	127.12	128.10	129.08	130.06	131.03
+-	18.62	18.86	19.10	19.34	19.58	19.82	20.07	20.31	20.55	20.80
170	132.01	132.99	133.97	134.95	135.92	136.90	137.88	138.86	139.84	140.82
+-	21.05	21.29	21.54	21.79	22.04	22.29	22.54	22.79	23.04	23.29
180	141.79	142.77	143.75	144.73	145.71	146.68	147.66	148.64	149.62	150.60
+-	23.54	23.80	24.05	24.30	24.56	24.81	25.07	25.32	25.58	25.83
190	151.57	152.55	153.53	154.51	155.49	156.47	157.44	158.42	159.40	160.38
+-	26.09	26.35	26.61	26.86	27.12	27.38	27.64	27.90	28.16	28.42
200	161.36	162.33	163.31	164.29	165.27	166.25	167.23	168.20	169.18	170.16
+-	28.68	28.94	29.20	29.46	29.72	29.99	30.25	30.51	30.77	31.03
210	171.14	172.12	173.09	174.07	175.05	176.03	177.01	177.98	178.96	179.94
+-	31.30	31.56	31.82	32.09	32.35	32.62	32.88	33.14	33.41	33.67

CONTINUED . . .

APPENDIX 10 CONTINUED

1968 TREE 9 CSCN = Y = -16.603 + 0.787TSCN

TSCN		0	1	2	3	4	5	6	7	8	9
60		30.60	31.39	32.18	32.96	33.75	34.54	35.32	36.11	36.90	37.68
	+-	27.80	27.46	27.12	26.78	26.44	26.10	25.77	25.43	25.10	24.77
70		38.47	39.26	40.04	40.83	41.62	42.40	43.19	43.98	44.76	45.55
	+-	24.44	24.11	23.79	23.46	23.14	22.82	22.50	22.19	21.88	21.56
80		46.34	47.12	47.91	48.70	49.48	50.27	51.06	51.84	52.63	53.42
	+-	21.26	20.95	20.65	20.35	20.05	19.75	19.46	19.17	18.89	18.61
90		54.20	54.99	55.78	56.56	57.35	58.14	58.92	59.71	60.50	61.29
	+-	18.33	18.06	17.79	17.53	17.27	17.01	16.76	16.52	16.28	16.04
100		62.07	62.86	63.65	64.43	65.22	66.01	66.79	67.58	68.37	69.15
	+-	15.82	15.59	15.38	15.17	14.97	14.78	14.59	14.41	14.24	14.08
110		69.94	70.73	71.51	72.30	73.09	73.87	74.66	75.45	76.23	77.02
	+-	13.93	13.79	13.65	13.53	13.42	13.31	13.22	13.14	13.07	13.00
120		77.81	78.59	79.38	80.17	80.95	81.74	82.53	83.31	84.10	84.89
	+-	12.96	12.92	12.89	12.88	12.87	12.88	12.90	12.93	12.98	13.03
130		85.67	86.46	87.25	88.03	88.82	89.61	90.39	91.18	91.97	92.76
	+-	13.09	13.17	13.26	13.36	13.46	13.58	13.71	13.85	13.99	14.15
140		93.54	94.33	95.12	95.90	96.69	97.48	98.26	99.05	99.84	100.62
	+-	14.32	14.49	14.67	14.86	15.06	15.26	15.47	15.69	15.91	16.14
150		101.41	102.20	102.98	103.77	104.56	105.34	106.13	106.92	107.70	108.49
	+-	16.38	16.62	16.87	17.12	17.38	17.64	17.90	18.17	18.45	18.73
160		109.28	110.06	110.85	111.64	112.42	113.21	114.00	114.78	115.57	116.36
	+-	19.01	19.30	19.59	19.88	20.17	20.47	20.78	21.08	21.39	21.70
170		117.14	117.93	118.72	119.50	120.29	121.08	121.86	122.65	123.44	124.23
	+-	22.01	22.32	22.64	22.96	23.28	23.60	23.93	24.25	24.58	24.91
180		125.01	125.80	126.59	127.37	128.16	128.95	129.73	130.52	131.31	132.09
	+-	25.24	25.58	25.91	26.25	26.58	26.92	27.26	27.60	27.95	28.29
190		132.88	133.67	134.45	135.24	136.03	136.81	137.60	138.39	139.17	139.96
	+-	28.63	28.98	29.33	29.67	30.02	30.37	30.72	31.07	31.43	31.78
200		140.75	141.53	142.32	143.11	143.89	144.68	145.47	146.25	147.04	147.83
	+-	32.13	32.49	32.84	33.20	33.55	33.91	34.27	34.63	34.99	35.35
210		148.61	149.40	150.19	150.97	151.76	152.55	153.33	154.12	154.91	155.70
	+-	35.71	36.07	36.43	36.79	37.15	37.51	37.88	38.24	38.60	38.97

CONTINUED . . .

APPENDIX 11

TABLES FOR ESTIMATION OF THE NUMBER OF CENTRAL SCALES (CSCN) PER CONE ACCORDING TO POSITION ON THE TREE

The tables provide estimates using the best predictive combination of a measure or relative height (RH1, RH2, RH3 or RH4) and shoot order (ORD) for each tree for which adequate data were obtained. These trees are numbers 1 to 10, 1964, numbers 1 to 12, 1966 and numbers 1, 2, 4 and 8, 1968.

N.B. The tables, as constructed, provide values for CSCN (many inordinately low) for some combinations of RH and ORD which are physically impossible.

APPENDIX 11

1964 TREE 1 CSCN = Y = -55.080 + 18.337X1

VARIABLE ORD NEGATIVE AND NON-SIGNIFICANT, THEREFORE EXCLUDED FROM EQUATION

X1 = RH2	Y	+-
6.0	54.94	50.31
6.2	58.61	49.67
6.4	62.28	49.06
6.6	65.95	48.48
6.8	69.61	47.93
7.0	73.28	47.42
7.1	75.11	47.18
7.2	76.95	46.94
7.3	78.78	46.72
7.4	80.62	46.51
7.5	82.45	46.30
7.6	84.28	46.11
7.7	86.12	45.92
7.8	87.95	45.75
7.9	89.78	45.58
8.0	91.62	45.43
8.1	93.45	45.28
8.2	95.29	45.15
8.3	97.12	45.02
8.4	98.95	44.91
8.5	100.79	44.81
8.6	102.62	44.71
8.7	104.45	44.63
8.8	106.29	44.56
8.9	108.12	44.50
9.0	109.96	44.45
9.1	111.79	44.41
9.2	113.62	44.39
9.3	115.46	44.37
9.4	117.29	44.36
9.5	119.12	44.37
9.6	120.96	44.39
9.7	122.79	44.41
9.8	124.62	44.45
9.9	126.46	44.50
10.0	128.29	44.56
10.1	130.13	44.63
10.2	131.96	44.71
10.3	133.79	44.81
10.4	135.63	44.91
10.5	137.46	45.02
11.0	146.63	45.75
11.5	155.80	46.72

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 2 CSCN = Y = -87.752 + 12.330X1 + 7.786X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	17.37	44.19	25.16	40.56	32.94	38.38	40.73	37.91	48.52	39.21
6.2	19.84	43.83	27.62	40.11	35.41	37.84	43.20	37.29	50.98	38.55
6.4	22.30	43.51	30.09	39.68	37.88	37.32	45.66	36.70	53.45	37.91
6.6	24.77	43.21	32.56	39.30	40.34	36.84	48.13	36.14	55.91	37.29
6.8	27.24	42.95	35.02	38.94	42.81	36.39	50.59	35.61	58.38	36.71
7.0	29.70	42.72	37.49	38.62	45.27	35.97	53.06	35.11	60.85	36.15
7.1	30.93	42.62	38.72	38.47	46.51	35.78	54.29	34.87	62.08	35.89
7.2	32.17	42.52	39.95	38.33	47.74	35.60	55.53	34.65	63.31	35.63
7.3	33.40	42.43	41.19	38.21	48.97	35.42	56.76	34.43	64.54	35.39
7.4	34.63	42.36	42.42	38.09	50.21	35.25	57.99	34.22	65.78	35.15
7.5	35.87	42.29	43.65	37.97	51.44	35.10	59.22	34.02	67.01	34.91
7.6	37.10	42.23	44.89	37.87	52.67	34.95	60.46	33.83	68.24	34.69
7.7	38.33	42.17	46.12	37.78	53.90	34.81	61.69	33.65	69.48	34.48
7.8	39.57	42.13	47.35	37.70	55.14	34.68	62.92	33.48	70.71	34.28
7.9	40.80	42.09	48.58	37.62	56.37	34.57	64.16	33.32	71.94	34.08
8.0	42.03	42.07	49.82	37.56	57.60	34.46	65.39	33.17	73.18	33.90
8.1	43.26	42.05	51.05	37.50	58.84	34.36	66.62	33.03	74.41	33.72
8.2	44.50	42.04	52.28	37.46	60.07	34.28	67.86	32.90	75.64	33.56
8.3	45.73	42.04	53.52	37.42	61.30	34.20	69.09	32.78	76.87	33.40
8.4	46.96	42.05	54.75	37.40	62.54	34.13	70.32	32.67	78.11	33.26
8.5	48.20	42.06	55.98	37.38	63.77	34.08	71.55	32.58	79.34	33.12
8.6	49.43	42.09	57.22	37.38	65.00	34.03	72.79	32.49	80.57	33.00
8.7	50.66	42.12	58.45	37.38	66.23	34.00	74.02	32.42	81.81	32.89
8.8	51.90	42.16	59.68	37.39	67.47	33.98	75.25	32.35	83.04	32.78
8.9	53.13	42.21	60.91	37.41	68.70	33.96	76.49	32.30	84.27	32.69
9.0	54.36	42.27	62.15	37.45	69.93	33.96	77.72	32.26	85.51	32.61
9.1	55.59	42.34	63.38	37.49	71.17	33.97	78.95	32.22	86.74	32.54
9.2	56.83	42.42	64.61	37.54	72.40	33.99	80.19	32.20	87.97	32.48
9.3	58.06	42.50	65.85	37.60	73.63	34.02	81.42	32.20	89.20	32.43
9.4	59.29	42.59	67.08	37.67	74.87	34.06	82.65	32.20	90.44	32.40
9.5	60.53	42.70	68.31	37.75	76.10	34.11	83.88	32.21	91.67	32.37
9.6	61.76	42.80	69.55	37.84	77.33	34.17	85.12	32.24	92.90	32.35
9.7	62.99	42.92	70.78	37.94	78.56	34.24	86.35	32.27	94.14	32.35
9.8	64.23	43.05	72.01	38.05	79.80	34.33	87.58	32.32	95.37	32.36
9.9	65.46	43.18	73.24	38.17	81.03	34.42	88.82	32.38	96.60	32.38
10.0	66.69	43.32	74.48	38.29	82.26	34.52	90.05	32.45	97.83	32.41
10.1	67.92	43.47	75.71	38.43	83.50	34.63	91.28	32.53	99.07	32.45
10.2	69.16	43.63	76.94	38.57	84.73	34.76	92.51	32.62	100.30	32.50
10.3	70.39	43.79	78.18	38.73	85.96	34.89	93.75	32.72	101.53	32.56
10.4	71.62	43.97	79.41	38.89	87.19	35.03	94.98	32.84	102.77	32.64
10.5	72.86	44.15	80.64	39.06	88.43	35.19	96.21	32.96	104.00	32.72
11.0	79.02	45.16	86.81	40.04	94.59	36.09	102.38	33.73	110.16	33.31
11.5							ORD 9 =		124.12	35.51

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 3 CSCN = Y = -88.961 + 14.469X1 + 8.672X2

X1 = RH2	X2 = ORD									
	4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	32.54	33.85	41.21	29.88	49.88	27.25	58.55	26.36	67.22	27.38
6.2	35.43	33.43	44.10	29.39	52.77	26.69	61.45	25.75	70.12	26.77
6.4	38.33	33.04	47.00	28.92	55.67	26.15	64.34	25.17	73.01	26.18
6.6	41.22	32.68	49.89	28.49	58.56	25.64	67.23	24.61	75.91	25.62
6.8	44.11	32.34	52.78	28.08	61.46	25.16	70.13	24.08	78.80	25.09
7.0	47.01	32.04	55.68	27.70	64.35	24.71	73.02	23.59	81.69	24.59
7.1	48.45	31.89	57.12	27.52	65.80	24.50	74.47	23.35	83.14	24.35
7.2	49.90	31.76	58.57	27.35	67.24	24.29	75.91	23.12	84.59	24.12
7.3	51.35	31.63	60.02	27.19	68.69	24.10	77.36	22.90	86.03	23.89
7.4	52.79	31.51	61.47	27.04	70.14	23.91	78.81	22.69	87.48	23.68
7.5	54.24	31.40	62.91	26.90	71.58	23.74	80.26	22.49	88.93	23.47
7.6	55.69	31.29	64.36	26.76	73.03	23.57	81.70	22.30	90.37	23.28
7.7	57.13	31.19	65.81	26.63	74.48	23.41	83.15	22.12	91.82	23.09
7.8	58.58	31.10	67.25	26.52	75.92	23.26	84.60	21.95	93.27	22.91
7.9	60.03	31.02	68.70	26.41	77.37	23.13	86.04	21.79	94.71	22.74
8.0	61.48	30.95	70.15	26.31	78.82	23.00	87.49	21.64	96.16	22.58
8.1	62.92	30.88	71.59	26.22	80.27	22.88	88.94	21.50	97.61	22.44
8.2	64.37	30.82	73.04	26.14	81.71	22.78	90.38	21.37	99.06	22.30
8.3	65.82	30.77	74.49	26.07	83.16	22.68	91.83	21.25	100.50	22.17
8.4	67.26	30.73	75.93	26.00	84.61	22.59	93.28	21.15	101.95	22.05
8.5	68.71	30.70	77.38	25.95	86.05	22.52	94.72	21.05	103.40	21.95
8.6	70.16	30.67	78.83	25.91	87.50	22.46	96.17	20.97	104.84	21.85
8.7	71.60	30.65	80.27	25.88	88.95	22.40	97.62	20.90	106.29	21.77
8.8	73.05	30.65	81.72	25.85	90.39	22.36	99.06	20.84	107.74	21.70
8.9	74.50	30.65	83.17	25.84	91.84	22.33	100.51	20.79	109.18	21.64
9.0	75.94	30.65	84.62	25.84	93.29	22.31	101.96	20.76	110.63	21.59
9.1	77.39	30.67	86.06	25.84	94.73	22.31	103.41	20.73	112.08	21.55
9.2	78.84	30.69	87.51	25.86	96.18	22.31	104.85	20.72	113.52	21.53
9.3	80.28	30.72	88.96	25.88	97.63	22.33	106.30	20.72	114.97	21.51
9.4	81.73	30.76	90.40	25.92	99.07	22.35	107.75	20.73	116.42	21.51
9.5	83.18	30.81	91.85	25.97	100.52	22.39	109.19	20.76	117.86	21.52
9.6	84.63	30.87	93.30	26.02	101.97	22.44	110.64	20.80	119.31	21.54
9.7	86.07	30.93	94.74	26.08	103.42	22.50	112.09	20.85	120.76	21.57
9.8	87.52	31.01	96.19	26.16	104.86	22.57	113.53	20.91	122.21	21.62
9.9	88.97	31.09	97.64	26.24	106.31	22.65	114.98	20.98	123.65	21.67
10.0	90.41	31.18	99.08	26.33	107.76	22.75	116.43	21.07	125.10	21.74
10.1	91.86	31.27	100.53	26.44	109.20	22.85	117.87	21.16	126.55	21.82
10.2	93.31	31.38	101.98	26.55	110.65	22.96	119.32	21.27	127.99	21.91
10.3	94.75	31.49	103.42	26.67	112.10	23.09	120.77	21.39	129.44	22.01
10.4	96.20	31.61	104.87	26.80	113.54	23.22	122.21	21.52	130.89	22.12
10.5	97.65	31.74	106.32	26.93	114.99	23.37	123.66	21.66	132.33	22.25
11.0	104.88	32.48	113.55	27.75	122.22	24.24	130.90	22.53	139.57	23.02
11.5								ORD 9 =	155.47	26.44

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 4 CSCN = Y = -41.275 + 8.991X1 + 8.772X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	47.76	35.14	56.53	34.64	65.30	34.45	74.08	34.60	82.85	35.07
6.2	49.56	35.12	58.33	34.59	67.10	34.38	75.87	34.51	84.65	34.95
6.4	51.36	35.11	60.13	34.55	68.90	34.32	77.67	34.42	86.44	34.85
6.6	53.15	35.10	61.93	34.52	70.70	34.27	79.47	34.34	88.24	34.75
6.8	54.95	35.10	63.72	34.50	72.50	34.22	81.27	34.27	90.04	34.66
7.0	56.75	35.11	65.52	34.48	74.29	34.18	83.07	34.21	91.84	34.57
7.1	57.65	35.11	66.42	34.48	75.19	34.16	83.97	34.18	92.74	34.53
7.2	58.55	35.12	67.32	34.47	76.09	34.15	84.86	34.15	93.64	34.49
7.3	59.45	35.13	68.22	34.47	76.99	34.13	85.76	34.13	94.54	34.45
7.4	60.35	35.14	69.12	34.47	77.89	34.12	86.66	34.10	95.43	34.42
7.5	61.25	35.15	70.02	34.47	78.79	34.11	87.56	34.08	96.33	34.39
7.6	62.15	35.17	70.92	34.48	79.69	34.10	88.46	34.06	97.23	34.35
7.7	63.04	35.18	71.82	34.48	80.59	34.10	89.36	34.04	98.13	34.32
7.8	63.94	35.20	72.72	34.49	81.49	34.09	90.26	34.03	99.03	34.29
7.9	64.84	35.22	73.61	34.49	82.39	34.09	91.16	34.01	99.93	34.27
8.0	65.74	35.24	74.51	34.50	83.29	34.09	92.06	34.00	100.83	34.24
8.1	66.64	35.27	75.41	34.52	84.18	34.09	92.96	33.99	101.73	34.22
8.2	67.54	35.29	76.31	34.53	85.08	34.09	93.86	33.98	102.63	34.20
8.3	68.44	35.32	77.21	34.54	85.98	34.09	94.75	33.97	103.53	34.18
8.4	69.34	35.34	78.11	34.56	86.88	34.10	95.65	33.96	104.43	34.16
8.5	70.24	35.37	79.01	34.58	87.78	34.10	96.55	33.96	105.32	34.14
8.6	71.14	35.40	79.91	34.60	88.68	34.11	97.45	33.95	106.22	34.13
8.7	72.04	35.44	80.81	34.62	89.58	34.12	98.35	33.95	107.12	34.12
8.8	72.93	35.47	81.71	34.65	90.48	34.13	99.25	33.95	108.02	34.10
8.9	73.83	35.51	82.61	34.67	91.38	34.15	100.15	33.95	108.92	34.09
9.0	74.73	35.54	83.50	34.70	92.28	34.16	101.05	33.96	109.82	34.09
9.1	75.63	35.58	84.40	34.73	93.18	34.18	101.95	33.96	110.72	34.08
9.2	76.53	35.63	85.30	34.76	94.07	34.20	102.85	33.97	111.62	34.08
9.3	77.43	35.67	86.20	34.79	94.97	34.22	103.75	33.98	112.52	34.07
9.4	78.33	35.71	87.10	34.82	95.87	34.24	104.64	33.99	113.42	34.07
9.5	79.23	35.76	88.00	34.86	96.77	34.27	105.54	34.01	114.32	34.07
9.6	80.13	35.81	88.90	34.90	97.67	34.30	106.44	34.02	115.21	34.08
9.7	81.03	35.85	89.80	34.93	98.57	34.32	107.34	34.04	116.11	34.08
9.8	81.93	35.91	90.70	34.98	99.47	34.35	108.24	34.05	117.01	34.09
9.9	82.82	35.96	91.60	35.02	100.37	34.38	109.14	34.07	117.91	34.10
10.0	83.72	36.01	92.50	35.06	101.27	34.42	110.04	34.10	118.81	34.11
10.1	84.62	36.07	93.39	35.11	102.17	34.45	110.94	34.12	119.71	34.12
10.2	85.52	36.12	94.29	35.15	103.07	34.49	111.84	34.14	120.61	34.13
10.3	86.42	36.18	95.19	35.20	103.96	34.53	112.74	34.17	121.51	34.15
10.4	87.32	36.24	96.09	35.25	104.86	34.57	113.64	34.20	122.41	34.16
10.5	88.22	36.30	96.99	35.31	105.76	34.61	114.54	34.23	123.31	34.18
11.0	92.71	36.64	101.49	35.59	110.26	34.84	119.03	34.41	127.80	34.30
11.5							ORD 9 =		141.07	34.63

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 5 CSCN = Y = -43.823 + 16.887X1

VARIABLE ORD NEGATIVE AND NON-SIGNIFICANT, THEREFORE EXCLUDED FROM EQUATION

X1 = RH2	Y	+-
6.0	57.50	51.98
6.2	60.87	51.48
6.4	64.25	51.01
6.6	67.63	50.57
6.8	71.01	50.16
7.0	74.38	49.77
7.1	76.07	49.59
7.2	77.76	49.41
7.3	79.45	49.24
7.4	81.14	49.08
7.5	82.83	48.93
7.6	84.52	48.79
7.7	86.20	48.65
7.8	87.89	48.52
7.9	89.58	48.40
8.0	91.27	48.29
8.1	92.96	48.18
8.2	94.65	48.09
8.3	96.34	48.00
8.4	98.03	47.92
8.5	99.71	47.85
8.6	101.40	47.78
8.7	103.09	47.73
8.8	104.78	47.68
8.9	106.47	47.64
9.0	108.16	47.61
9.1	109.85	47.59
9.2	111.53	47.58
9.3	113.22	47.57
9.4	114.91	47.57
9.5	116.60	47.59
9.6	118.29	47.61
9.7	119.98	47.63
9.8	121.67	47.67
9.9	123.36	47.72
10.0	125.04	47.77
10.1	126.73	47.83
10.2	128.42	47.90
10.3	130.11	47.98
10.4	131.80	48.07
10.5	133.49	48.16
11.0	141.93	48.76
11.5	150.37	49.55

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 6 CSCN = Y = 35.784 + 6.941X1

VARIABLE ORD NEGATIVE AND NON-SIGNIFICANT, THEREFORE EXCLUDED FROM EQUATION

X1 = RH1	Y	+-
5.0	70.49	76.27
5.5	73.96	67.64
6.0	77.43	59.12
6.5	80.90	50.78
7.0	84.37	42.70
7.5	87.84	35.09
8.0	91.31	28.32
8.5	94.78	23.13
9.0	98.26	20.75
9.5	101.73	22.11
10.0	105.20	26.64
10.5	108.67	33.06

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 7 CSCN = Y =-100.459 + 12.624X1 + 11.482X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	21.21	29.07	32.70	27.95	44.18	27.67	55.66	28.25	67.14	29.64
6.2	23.74	28.69	35.22	27.48	46.70	27.11	58.19	27.62	69.67	28.97
6.4	26.26	28.34	37.75	27.03	49.23	26.58	60.71	27.02	72.19	28.32
6.6	28.79	28.03	40.27	26.62	51.75	26.08	63.24	26.45	74.72	27.69
6.8	31.31	27.75	42.80	26.25	54.28	25.61	65.76	25.90	77.24	27.08
7.0	33.84	27.51	45.32	25.90	56.80	25.17	68.29	25.38	79.77	26.51
7.1	35.10	27.40	46.58	25.75	58.06	24.96	69.55	25.13	81.03	26.23
7.2	36.36	27.30	47.84	25.60	59.33	24.77	70.81	24.89	82.29	25.96
7.3	37.62	27.21	49.11	25.46	60.59	24.58	72.07	24.66	83.55	25.69
7.4	38.89	27.13	50.37	25.33	61.85	24.40	73.33	24.44	84.82	25.43
7.5	40.15	27.06	51.63	25.21	63.11	24.23	74.60	24.22	86.08	25.19
7.6	41.41	27.00	52.89	25.10	64.38	24.07	75.86	24.02	87.34	24.94
7.7	42.67	26.95	54.16	25.00	65.64	23.92	77.12	23.82	88.60	24.71
7.8	43.94	26.90	55.42	24.91	66.90	23.78	78.38	23.64	89.87	24.49
7.9	45.20	26.87	56.68	24.84	68.16	23.65	79.65	23.46	91.13	24.27
8.0	46.46	26.85	57.94	24.77	69.43	23.54	80.91	23.29	92.39	24.07
8.1	47.72	26.84	59.21	24.71	70.69	23.43	82.17	23.14	93.65	23.87
8.2	48.99	26.83	60.47	24.66	71.95	23.33	83.43	22.99	94.92	23.68
8.3	50.25	26.84	61.73	24.62	73.21	23.25	84.70	22.85	96.18	23.50
8.4	51.51	26.86	62.99	24.60	74.48	23.17	85.96	22.73	97.44	23.33
8.5	52.77	26.88	64.26	24.58	75.74	23.11	87.22	22.62	98.70	23.18
8.6	54.04	26.92	65.52	24.58	77.00	23.05	88.48	22.51	99.97	23.03
8.7	55.30	26.97	66.78	24.58	78.26	23.01	89.75	22.42	101.23	22.89
8.8	56.56	27.02	68.04	24.60	79.53	22.98	91.01	22.34	102.49	22.77
8.9	57.82	27.09	69.31	24.63	80.79	22.96	92.27	22.27	103.75	22.65
9.0	59.09	27.16	70.57	24.66	82.05	22.96	93.53	22.22	105.02	22.55
9.1	60.35	27.24	71.83	24.71	83.31	22.96	94.80	22.17	106.28	22.45
9.2	61.61	27.34	73.09	24.77	84.57	22.97	96.06	22.14	107.54	22.37
9.3	62.87	27.44	74.35	24.84	85.84	23.00	97.32	22.12	108.80	22.30
9.4	64.13	27.55	75.62	24.92	87.10	23.04	98.58	22.11	110.06	22.24
9.5	65.40	27.67	76.88	25.01	88.36	23.09	99.84	22.11	111.33	22.19
9.6	66.66	27.80	78.14	25.11	89.62	23.15	101.11	22.12	112.59	22.16
9.7	67.92	27.94	79.40	25.22	90.89	23.22	102.37	22.15	113.85	22.13
9.8	69.18	28.09	80.67	25.34	92.15	23.31	103.63	22.19	115.11	22.12
9.9	70.45	28.24	81.93	25.47	93.41	23.40	104.89	22.24	116.38	22.12
10.0	71.71	28.41	83.19	25.61	94.67	23.50	106.16	22.30	117.64	22.14
10.1	72.97	28.58	84.45	25.76	95.94	23.62	107.42	22.37	118.90	22.16
10.2	74.23	28.76	85.72	25.91	97.20	23.75	108.68	22.46	120.16	22.19
10.3	75.50	28.95	86.98	26.08	98.46	23.88	109.94	22.55	121.43	22.24
10.4	76.76	29.15	88.24	26.26	99.72	24.03	111.21	22.66	122.69	22.30
10.5	78.02	29.35	89.50	26.44	100.99	24.19	112.47	22.78	123.95	22.37
11.0	84.33	30.48	95.82	27.49	107.30	25.11	118.78	23.52	130.26	22.90
11.5								ORD 9 =	148.06	23.85

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 8 CSCN = Y = -82.063 + 9.673X1 + 8.828X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	11.29	31.19	20.11	29.08	28.94	28.74	37.77	30.23	46.60	33.31
6.2	13.22	30.45	22.05	28.10	30.88	27.56	39.70	28.93	48.53	31.97
6.4	15.15	29.75	23.98	27.15	32.81	26.40	41.64	27.64	50.47	30.64
6.6	17.09	29.11	25.92	26.25	34.74	25.27	43.57	26.37	52.40	29.32
6.8	19.02	28.53	27.85	25.40	36.68	24.17	45.51	25.11	54.33	28.01
7.0	20.96	28.01	29.79	24.61	38.61	23.11	47.44	23.87	56.27	26.71
7.1	21.93	27.77	30.75	24.23	39.58	22.59	48.41	23.26	57.24	26.07
7.2	22.89	27.55	31.72	23.87	40.55	22.08	49.38	22.66	58.20	25.43
7.3	23.86	27.34	32.69	23.52	41.52	21.59	50.34	22.06	59.17	24.79
7.4	24.83	27.16	33.65	23.19	42.48	21.11	51.31	21.47	60.14	24.16
7.5	25.79	26.99	34.62	22.88	43.45	20.64	52.28	20.88	61.11	23.53
7.6	26.76	26.84	35.59	22.59	44.42	20.19	53.24	20.31	62.07	22.91
7.7	27.73	26.70	36.56	22.31	45.38	19.75	54.21	19.74	63.04	22.29
7.8	28.70	26.59	37.52	22.06	46.35	19.33	55.18	19.19	64.01	21.68
7.9	29.66	26.49	38.49	21.82	47.32	18.92	56.15	18.64	64.97	21.08
8.0	30.63	26.42	39.46	21.61	48.29	18.54	57.11	18.11	65.94	20.48
8.1	31.60	26.36	40.43	21.42	49.25	18.17	58.08	17.58	66.91	19.89
8.2	32.57	26.32	41.39	21.25	50.22	17.83	59.05	17.08	67.88	19.31
8.3	33.53	26.30	42.36	21.10	51.19	17.51	60.02	16.58	68.84	18.74
8.4	34.50	26.30	43.33	20.98	52.16	17.21	60.98	16.11	69.81	18.18
8.5	35.47	26.32	44.30	20.88	53.12	16.94	61.95	15.65	70.78	17.62
8.6	36.43	26.36	45.26	20.81	54.09	16.69	62.92	15.21	71.75	17.09
8.7	37.40	26.42	46.23	20.76	55.06	16.47	63.89	14.80	72.71	16.56
8.8	38.37	26.50	47.20	20.73	56.02	16.28	64.85	14.41	73.68	16.05
8.9	39.34	26.59	48.16	20.73	56.99	16.11	65.82	14.04	74.65	15.55
9.0	40.30	26.71	49.13	20.75	57.96	15.98	66.79	13.70	75.61	15.08
9.1	41.27	26.84	50.10	20.80	58.93	15.88	67.75	13.39	76.58	14.62
9.2	42.24	26.99	51.07	20.87	59.89	15.81	68.72	13.11	77.55	14.18
9.3	43.21	27.16	52.03	20.97	60.86	15.77	69.69	12.86	78.52	13.77
9.4	44.17	27.35	53.00	21.09	61.83	15.77	70.66	12.65	79.48	13.38
9.5	45.14	27.56	53.97	21.23	62.80	15.79	71.62	12.48	80.45	13.02
9.6	46.11	27.78	54.94	21.39	63.76	15.85	72.59	12.35	81.42	12.69
9.7	47.07	28.01	55.90	21.58	64.73	15.95	73.56	12.25	82.39	12.39
9.8	48.04	28.27	56.87	21.79	65.70	16.07	74.53	12.20	83.35	12.13
9.9	49.01	28.54	57.84	22.02	66.66	16.22	75.49	12.19	84.32	11.90
10.0	49.98	28.82	58.80	22.27	67.63	16.40	76.46	12.22	85.29	11.71
10.1	50.94	29.12	59.77	22.55	68.60	16.61	77.43	12.30	86.25	11.57
10.2	51.91	29.44	60.74	22.84	69.57	16.85	78.39	12.41	87.22	11.46
10.3	52.88	29.76	61.71	23.15	70.53	17.12	79.36	12.56	88.19	11.41
10.4	53.85	30.10	62.67	23.47	71.50	17.41	80.33	12.75	89.16	11.39
10.5	54.81	30.46	63.64	23.82	72.47	17.72	81.30	12.98	90.12	11.42
11.0	59.65	32.41	68.48	25.76	77.30	19.61	86.13	14.60	94.96	12.21
11.5								ORD 9 =	108.62	14.52

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 9 CSCN = Y = -40.885 + 8.073X1 + 7.471X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	37.43	23.39	44.90	20.85	52.38	19.22	59.85	18.75	67.32	19.51
6.2	39.05	23.02	46.52	20.41	53.99	18.72	61.46	18.21	68.93	18.98
6.4	40.66	22.67	48.13	19.99	55.60	18.24	63.08	17.69	70.55	18.46
6.6	42.28	22.34	49.75	19.59	57.22	17.78	64.69	17.19	72.16	17.95
6.8	43.89	22.03	51.36	19.22	58.83	17.34	66.30	16.71	73.78	17.47
7.0	45.51	21.75	52.98	18.87	60.45	16.93	67.92	16.26	75.39	17.01
7.1	46.31	21.61	53.78	18.70	61.26	16.73	68.73	16.04	76.20	16.79
7.2	47.12	21.49	54.59	18.55	62.06	16.54	69.53	15.83	77.00	16.57
7.3	47.93	21.37	55.40	18.39	62.87	16.36	70.34	15.62	77.81	16.36
7.4	48.74	21.25	56.21	18.25	63.68	16.18	71.15	15.42	78.62	16.16
7.5	49.54	21.14	57.01	18.11	64.48	16.01	71.96	15.23	79.43	15.96
7.6	50.35	21.04	57.82	17.98	65.29	15.85	72.76	15.05	80.23	15.78
7.7	51.16	20.95	58.63	17.86	66.10	15.70	73.57	14.87	81.04	15.59
7.8	51.97	20.86	59.44	17.74	66.91	15.55	74.38	14.70	81.85	15.42
7.9	52.77	20.78	60.24	17.64	67.71	15.42	75.18	14.54	82.66	15.25
8.0	53.58	20.70	61.05	17.54	68.52	15.29	75.99	14.39	83.46	15.10
8.1	54.39	20.64	61.86	17.45	69.33	15.17	76.80	14.25	84.27	14.95
8.2	55.19	20.58	62.66	17.36	70.14	15.06	77.61	14.12	85.08	14.81
8.3	56.00	20.52	63.47	17.29	70.94	14.96	78.41	14.00	85.88	14.68
8.4	56.81	20.48	64.28	17.22	71.75	14.87	79.22	13.88	86.69	14.55
8.5	57.62	20.44	65.09	17.16	72.56	14.79	80.03	13.78	87.50	14.44
8.6	58.42	20.41	65.89	17.11	73.36	14.71	80.84	13.69	88.31	14.34
8.7	59.23	20.39	66.70	17.07	74.17	14.65	81.64	13.61	89.11	14.24
8.8	60.04	20.37	67.51	17.04	74.98	14.60	82.45	13.53	89.92	14.16
8.9	60.85	20.36	68.32	17.02	75.79	14.56	83.26	13.47	90.73	14.09
9.0	61.65	20.36	69.12	17.00	76.59	14.53	84.06	13.42	91.54	14.02
9.1	62.46	20.37	69.93	17.00	77.40	14.51	84.87	13.38	92.34	13.97
9.2	63.27	20.38	70.74	17.00	78.21	14.49	85.68	13.36	93.15	13.93
9.3	64.07	20.40	71.55	17.01	79.02	14.49	86.49	13.34	93.96	13.90
9.4	64.88	20.43	72.35	17.04	79.82	14.50	87.29	13.34	94.76	13.88
9.5	65.69	20.46	73.16	17.06	80.63	14.52	88.10	13.34	95.57	13.87
9.6	66.50	20.51	73.97	17.10	81.44	14.56	88.91	13.36	96.38	13.87
9.7	67.30	20.56	74.77	17.15	82.24	14.60	89.72	13.39	97.19	13.88
9.8	68.11	20.61	75.58	17.21	83.05	14.65	90.52	13.43	97.99	13.90
9.9	68.92	20.68	76.39	17.27	83.86	14.71	91.33	13.48	98.80	13.94
10.0	69.73	20.75	77.20	17.34	84.67	14.78	92.14	13.54	99.61	13.98
10.1	70.53	20.83	78.00	17.43	85.47	14.86	92.94	13.61	100.42	14.04
10.2	71.34	20.91	78.81	17.52	86.28	14.95	93.75	13.70	101.22	14.10
10.3	72.15	21.00	79.62	17.61	87.09	15.05	94.56	13.79	102.03	14.18
10.4	72.95	21.10	80.43	17.72	87.90	15.16	95.37	13.89	102.84	14.27
10.5	73.76	21.21	81.23	17.83	88.70	15.28	96.17	14.01	103.64	14.36
11.0	77.80	21.83	85.27	18.51	92.74	16.00	100.21	14.72	107.68	14.98
11.5								ORD 9 =	119.19	17.42

CONTINUED . . .

APPENDIX 11 CONTINUED

1964 TREE 10 CSCN = Y =-167.335 + 8.501X1 + 24.307X2

X1 = RH4	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
4.5	-31.85	36.88	-7.55	37.76	16.76	41.71	41.07	47.98	65.37	55.79
5.0	-27.60	34.29	-3.30	34.23	21.01	37.63	45.32	43.69	69.62	51.48
5.5	-23.35	32.11	0.95	30.95	25.26	33.66	49.57	39.45	73.88	47.20
6.0	-19.10	30.43	5.20	27.99	29.51	29.81	53.82	35.25	78.13	42.95
6.5	-14.85	29.33	9.46	25.46	33.76	26.16	58.07	31.12	82.38	38.75
6.6	-14.00	29.19	10.31	25.02	34.61	25.46	58.92	30.31	83.23	37.91
6.7	-13.15	29.07	11.16	24.60	35.46	24.77	59.77	29.50	84.08	37.08
6.8	-12.30	28.98	12.01	24.21	36.31	24.09	60.62	28.69	84.93	36.25
6.9	-11.45	28.92	12.86	23.84	37.16	23.43	61.47	27.89	85.78	35.43
7.0	-10.60	28.88	13.71	23.51	38.01	22.79	62.32	27.10	86.63	34.61
7.1	-9.75	28.88	14.56	23.20	38.86	22.16	63.17	26.31	87.48	33.79
7.2	-8.90	28.90	15.41	22.92	39.71	21.55	64.02	25.53	88.33	32.97
7.3	-8.05	28.94	16.26	22.68	40.56	20.96	64.87	24.75	89.18	32.16
7.4	-7.20	29.02	17.11	22.47	41.41	20.39	65.72	23.98	90.03	31.35
7.5	-6.35	29.12	17.96	22.29	42.26	19.85	66.57	23.22	90.88	30.55
7.6	-5.50	29.24	18.81	22.14	43.11	19.33	67.42	22.48	91.73	29.75
7.7	-4.65	29.40	19.66	22.03	43.96	18.83	68.27	21.74	92.58	28.96
7.8	-3.80	29.58	20.51	21.96	44.81	18.37	69.12	21.01	93.43	28.17
7.9	-2.95	29.78	21.36	21.92	45.66	17.94	69.97	20.30	94.28	27.39
8.0	-2.10	30.01	22.21	21.91	46.51	17.55	70.82	19.60	95.13	26.62
8.1	-1.25	30.27	23.06	21.95	47.36	17.19	71.67	18.91	95.98	25.85
8.2	-0.40	30.55	23.91	22.02	48.21	16.87	72.52	18.25	96.83	25.09
8.3	0.45	30.85	24.76	22.12	49.06	16.60	73.37	17.60	97.68	24.34
8.4	1.30	31.17	25.61	22.26	49.91	16.36	74.22	16.98	98.53	23.60
8.5	2.15	31.52	26.46	22.43	50.76	16.17	75.07	16.38	99.38	22.87
8.6	3.00	31.88	27.31	22.64	51.61	16.03	75.92	15.81	100.23	22.16
8.7	3.85	32.27	28.16	22.88	52.46	15.94	76.77	15.26	101.08	21.45
8.8	4.70	32.68	29.01	23.16	53.31	15.90	77.62	14.76	101.93	20.76
8.9	5.55	33.10	29.86	23.46	54.16	15.91	78.47	14.29	102.78	20.09
9.0	6.40	33.55	30.71	23.79	55.01	15.96	79.32	13.86	103.63	19.43
9.1	7.25	34.01	31.56	24.15	55.86	16.07	80.17	13.47	104.48	18.79
9.2	8.10	34.49	32.41	24.54	56.71	16.22	81.02	13.14	105.33	18.17
9.3	8.95	34.98	33.26	24.95	57.56	16.42	81.87	12.85	106.18	17.58
9.4	9.80	35.49	34.11	25.39	58.41	16.67	82.72	12.63	107.03	17.01
9.5	10.65	36.02	34.96	25.85	59.26	16.96	83.57	12.46	107.88	16.47
9.6	11.50	36.55	35.81	26.33	60.11	17.29	84.42	12.35	108.73	15.96
9.7	12.35	37.11	36.66	26.83	60.97	17.65	85.27	12.31	109.58	15.49
9.8	13.20	37.67	37.51	27.36	61.82	18.06	86.12	12.34	110.43	15.05
9.9	14.05	38.25	38.36	27.90	62.67	18.50	86.97	12.42	111.28	14.66
10.0	14.90	38.84	39.21	28.46	63.52	18.97	87.82	12.57	112.13	14.31
10.1	15.75	39.44	40.06	29.03	64.37	19.47	88.67	12.78	112.98	14.00
10.2	16.60	40.05	40.91	29.62	65.22	19.99	89.52	13.05	113.83	13.75
10.5	19.15	41.94	43.46	31.48	67.77	21.72	92.07	14.16	116.38	13.32
10.8								ORD 9 =	143.24	19.08

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 1 CSCN = Y = -39.725 + 12.057X1 + 9.082X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	68.94	32.05	78.02	31.57	87.10	31.51	96.19	31.87	105.27	32.65
6.2	71.35	31.95	80.43	31.43	89.52	31.34	98.60	31.67	107.68	32.42
6.4	73.76	31.87	82.85	31.31	91.93	31.18	101.01	31.48	110.09	32.20
6.6	76.18	31.80	85.26	31.21	94.34	31.04	103.42	31.31	112.50	31.99
6.8	78.59	31.74	87.67	31.12	96.75	30.91	105.83	31.14	114.91	31.79
7.0	81.00	31.70	90.08	31.04	99.16	30.80	108.24	30.99	117.32	31.61
7.1	82.20	31.69	91.29	31.00	100.37	30.75	109.45	30.92	118.53	31.53
7.2	83.41	31.67	92.49	30.97	101.57	30.70	110.65	30.86	119.74	31.44
7.3	84.62	31.66	93.70	30.95	102.78	30.65	111.86	30.79	120.94	31.36
7.4	85.82	31.66	94.90	30.92	103.98	30.61	113.07	30.73	122.15	31.29
7.5	87.03	31.66	96.11	30.90	105.19	30.57	114.27	30.68	123.35	31.21
7.6	88.23	31.66	97.31	30.89	106.40	30.54	115.48	30.62	124.56	31.15
7.7	89.44	31.66	98.52	30.87	107.60	30.51	116.68	30.58	125.76	31.08
7.8	90.64	31.67	99.73	30.86	108.81	30.48	117.89	30.53	126.97	31.02
7.9	91.85	31.68	100.93	30.86	110.01	30.45	119.09	30.49	128.18	30.96
8.0	93.05	31.70	102.14	30.86	111.22	30.43	120.30	30.45	129.38	30.90
8.1	94.26	31.72	103.34	30.86	112.42	30.42	121.51	30.41	130.59	30.85
8.2	95.47	31.74	104.55	30.86	113.63	30.40	122.71	30.38	131.79	30.80
8.3	96.67	31.77	105.75	30.87	114.84	30.40	123.92	30.36	133.00	30.76
8.4	97.88	31.80	106.96	30.88	116.04	30.39	125.12	30.33	134.20	30.71
8.5	99.08	31.83	108.16	30.90	117.25	30.39	126.33	30.31	135.41	30.68
8.6	100.29	31.87	109.37	30.92	118.45	30.39	127.53	30.29	136.62	30.64
8.7	101.49	31.91	110.58	30.94	119.66	30.39	128.74	30.28	137.82	30.61
8.8	102.70	31.95	111.78	30.97	120.86	30.40	129.95	30.27	139.03	30.58
8.9	103.91	31.99	112.99	31.00	122.07	30.42	131.15	30.27	140.23	30.56
9.0	105.11	32.04	114.19	31.03	123.27	30.43	132.36	30.26	141.44	30.54
9.1	106.32	32.10	115.40	31.07	124.48	30.45	133.56	30.27	142.64	30.52
9.2	107.52	32.15	116.60	31.11	125.69	30.47	134.77	30.27	143.85	30.51
9.3	108.73	32.21	117.81	31.16	126.89	30.50	135.97	30.28	145.06	30.50
9.4	109.93	32.28	119.02	31.20	128.10	30.53	137.18	30.29	146.26	30.49
9.5	111.14	32.34	120.22	31.25	129.30	30.57	138.39	30.31	147.47	30.49
9.6	112.35	32.41	121.43	31.31	130.51	30.60	139.59	30.33	148.67	30.49
9.7	113.55	32.49	122.63	31.37	131.71	30.64	140.80	30.35	149.88	30.50
9.8	114.76	32.56	123.84	31.43	132.92	30.69	142.00	30.38	151.08	30.51
9.9	115.96	32.64	125.04	31.49	134.13	30.74	143.21	30.41	152.29	30.52
10.0	117.17	32.73	126.25	31.56	135.33	30.79	144.41	30.44	153.50	30.53
10.1	118.37	32.81	127.46	31.63	136.54	30.84	145.62	30.48	154.70	30.55
10.2	119.58	32.90	128.66	31.71	137.74	30.90	146.82	30.52	155.91	30.58
10.3	120.79	32.99	129.87	31.78	138.95	30.97	148.03	30.57	157.11	30.60
10.4	121.99	33.09	131.07	31.87	140.15	31.03	149.24	30.61	158.32	30.63
10.5	123.20	33.19	132.28	31.95	141.36	31.10	150.44	30.67	159.52	30.67
11.0	129.22	33.72	138.31	32.42	147.39	31.50	156.47	30.98	165.55	30.89
11.5								ORD 9 =	180.66	31.45

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 2 CSCN = Y = -1.886 + 8.007X1 + 4.499X2

X1 = RH4	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
4.5	52.14	25.53	56.64	25.12	61.14	24.98	65.64	25.11	70.14	25.50
5.0	56.14	25.37	60.64	24.93	65.14	24.74	69.64	24.83	74.14	25.19
5.5	60.15	25.26	64.65	24.77	69.15	24.54	73.65	24.59	78.14	24.91
6.0	64.15	25.18	68.65	24.65	73.15	24.38	77.65	24.39	82.15	24.67
6.5	68.16	25.14	72.65	24.56	77.15	24.26	81.65	24.22	86.15	24.47
6.6	68.96	25.13	73.45	24.55	77.95	24.24	82.45	24.20	86.95	24.43
6.7	69.76	25.13	74.26	24.54	78.75	24.22	83.25	24.17	87.75	24.40
6.8	70.56	25.13	75.06	24.53	79.56	24.20	84.05	24.14	88.55	24.36
6.9	71.36	25.13	75.86	24.52	80.36	24.18	84.86	24.12	89.35	24.33
7.0	72.16	25.13	76.66	24.52	81.16	24.17	85.66	24.10	90.15	24.30
7.1	72.96	25.14	77.46	24.51	81.96	24.16	86.46	24.07	90.96	24.27
7.2	73.76	25.14	78.26	24.51	82.76	24.15	87.26	24.05	91.76	24.24
7.3	74.56	25.15	79.06	24.51	83.56	24.14	88.06	24.04	92.56	24.22
7.4	75.36	25.16	79.86	24.51	84.36	24.13	88.86	24.02	93.36	24.19
7.5	76.16	25.16	80.66	24.51	85.16	24.12	89.66	24.01	94.16	24.17
7.6	76.96	25.18	81.46	24.51	85.96	24.12	90.46	23.99	94.96	24.15
7.7	77.76	25.19	82.26	24.52	86.76	24.11	91.26	23.98	95.76	24.13
7.8	78.56	25.20	83.06	24.52	87.56	24.11	92.06	23.97	96.56	24.11
7.9	79.37	25.22	83.86	24.53	88.36	24.11	92.86	23.96	97.36	24.09
8.0	80.17	25.23	84.66	24.54	89.16	24.11	93.66	23.95	98.16	24.08
8.1	80.97	25.25	85.47	24.55	89.96	24.11	94.46	23.95	98.96	24.06
8.2	81.77	25.27	86.27	24.56	90.77	24.12	95.26	23.94	99.76	24.05
8.3	82.57	25.29	87.07	24.58	91.57	24.12	96.06	23.94	100.56	24.04
8.4	83.37	25.32	87.87	24.59	92.37	24.13	96.87	23.94	101.36	24.03
8.5	84.17	25.34	88.67	24.61	93.17	24.14	97.67	23.94	102.17	24.02
8.6	84.97	25.36	89.47	24.63	93.97	24.15	98.47	23.94	102.97	24.02
8.7	85.77	25.39	90.27	24.65	94.77	24.16	99.27	23.95	103.77	24.01
8.8	86.57	25.42	91.07	24.67	95.57	24.17	100.07	23.95	104.57	24.01
8.9	87.37	25.45	91.87	24.69	96.37	24.19	100.87	23.96	105.37	24.01
9.0	88.17	25.48	92.67	24.72	97.17	24.21	101.67	23.97	106.17	24.01
9.1	88.97	25.51	93.47	24.74	97.97	24.22	102.47	23.98	106.97	24.01
9.2	89.77	25.55	94.27	24.77	98.77	24.24	103.27	23.99	107.77	24.01
9.3	90.57	25.58	95.07	24.80	99.57	24.26	104.07	24.00	108.57	24.02
9.4	91.38	25.62	95.87	24.83	100.37	24.29	104.87	24.02	109.37	24.02
9.5	92.18	25.66	96.68	24.86	101.17	24.31	105.67	24.03	110.17	24.03
9.6	92.98	25.70	97.48	24.89	101.97	24.34	106.47	24.05	110.97	24.04
9.7	93.78	25.74	98.28	24.93	102.78	24.36	107.27	24.07	111.77	24.05
9.8	94.58	25.78	99.08	24.96	103.58	24.39	108.08	24.09	112.57	24.06
9.9	95.38	25.83	99.88	25.00	104.38	24.42	108.88	24.11	113.38	24.08
10.0	96.18	25.87	100.68	25.04	105.18	24.45	109.68	24.14	114.18	24.09
10.1	96.98	25.92	101.48	25.08	105.98	24.49	110.48	24.16	114.98	24.11
10.2	97.78	25.97	102.28	25.12	106.78	24.52	111.28	24.19	115.78	24.13
10.5	100.18	26.12	104.68	25.25	109.18	24.63	113.68	24.28	118.18	24.20
10.8								ORD 9 =	125.08	24.44

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 3 CSCN = Y = -11.245 + 6.909X1 + 8.174X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	62.90	28.85	71.08	28.02	79.25	27.91	87.43	28.52	95.60	29.80
6.2	64.29	28.69	72.46	27.80	80.63	27.61	88.81	28.16	96.98	29.40
6.4	65.67	28.56	73.84	27.59	82.02	27.34	90.19	27.83	98.36	29.01
6.6	67.05	28.45	75.22	27.41	83.40	27.09	91.57	27.51	99.75	28.65
6.8	68.43	28.37	76.61	27.26	84.78	26.86	92.95	27.22	101.13	28.30
7.0	69.81	28.31	77.99	27.12	86.16	26.66	94.34	26.95	102.51	27.97
7.1	70.50	28.29	78.68	27.07	86.85	26.57	95.03	26.82	103.20	27.82
7.2	71.20	28.27	79.37	27.02	87.54	26.48	95.72	26.70	103.89	27.67
7.3	71.89	28.26	80.06	26.97	88.23	26.40	96.41	26.59	104.58	27.53
7.4	72.58	28.26	80.75	26.94	88.93	26.33	97.10	26.48	105.27	27.39
7.5	73.27	28.26	81.44	26.91	89.62	26.26	97.79	26.38	105.96	27.26
7.6	73.96	28.27	82.13	26.88	90.31	26.20	98.48	26.28	106.65	27.13
7.7	74.65	28.29	82.82	26.86	91.00	26.15	99.17	26.19	107.35	27.01
7.8	75.34	28.31	83.52	26.85	91.69	26.10	99.86	26.11	108.04	26.89
7.9	76.03	28.34	84.21	26.85	92.38	26.06	100.55	26.03	108.73	26.78
8.0	76.72	28.37	84.90	26.85	93.07	26.02	101.24	25.96	109.42	26.68
8.1	77.41	28.41	85.59	26.85	93.76	25.99	101.94	25.90	110.11	26.58
8.2	78.10	28.46	86.28	26.87	94.45	25.97	102.63	25.84	110.80	26.49
8.3	78.80	28.51	86.97	26.89	95.14	25.96	103.32	25.79	111.49	26.41
8.4	79.49	28.57	87.66	26.92	95.83	25.95	104.01	25.75	112.18	26.33
8.5	80.18	28.63	88.35	26.95	96.53	25.95	104.70	25.71	112.87	26.25
8.6	80.87	28.70	89.04	26.99	97.22	25.95	105.39	25.68	113.56	26.19
8.7	81.56	28.78	89.73	27.03	97.91	25.97	106.08	25.65	114.25	26.13
8.8	82.25	28.86	90.42	27.09	98.60	25.98	106.77	25.64	114.95	26.08
8.9	82.94	28.94	91.11	27.14	99.29	26.01	107.46	25.63	115.64	26.03
9.0	83.63	29.04	91.81	27.21	99.98	26.04	108.15	25.62	116.33	25.99
9.1	84.32	29.13	92.50	27.28	100.67	26.08	108.84	25.62	117.02	25.96
9.2	85.01	29.24	93.19	27.36	101.36	26.12	109.54	25.63	117.71	25.93
9.3	85.70	29.35	93.88	27.44	102.05	26.17	110.23	25.65	118.40	25.91
9.4	86.40	29.46	94.57	27.53	102.74	26.23	110.92	25.67	119.09	25.90
9.5	87.09	29.58	95.26	27.62	103.43	26.30	111.61	25.70	119.78	25.89
9.6	87.78	29.71	95.95	27.72	104.13	26.37	112.30	25.74	120.47	25.89
9.7	88.47	29.84	96.64	27.83	104.82	26.44	112.99	25.78	121.16	25.90
9.8	89.16	29.98	97.33	27.94	105.51	26.53	113.68	25.83	121.85	25.91
9.9	89.85	30.12	98.02	28.06	106.20	26.62	114.37	25.89	122.55	25.93
10.0	90.54	30.26	98.71	28.19	106.89	26.71	115.06	25.95	123.24	25.96
10.1	91.23	30.41	99.41	28.32	107.58	26.82	115.75	26.02	123.93	25.99
10.2	91.92	30.57	100.10	28.45	108.27	26.92	116.44	26.09	124.62	26.03
10.3	92.61	30.73	100.79	28.59	108.96	27.04	117.14	26.18	125.31	26.08
10.4	93.30	30.90	101.48	28.74	109.65	27.16	117.83	26.26	126.00	26.13
10.5	94.00	31.07	102.17	28.89	110.34	27.28	118.52	26.36	126.69	26.19
11.0	97.45	31.99	105.62	29.72	113.80	27.99	121.97	26.92	130.15	26.58
11.5								ORD 9 =	141.77	27.37

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 4 CSCN = Y = -0.299 + 13.683X1 + 3.072X2

X1 = RH3	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
4.0	66.72	27.61	69.79	27.38	72.86	27.48	75.94	27.91	79.01	28.65
5.0	80.40	27.11	83.48	26.71	86.55	26.65	89.62	26.92	92.69	27.53
5.5	87.24	26.97	90.32	26.48	93.39	26.33	96.46	26.53	99.53	27.06
6.0	94.09	26.90	97.16	26.32	100.23	26.09	103.30	26.20	106.37	26.66
6.2	96.82	26.89	99.89	26.28	102.97	26.01	106.04	26.09	109.11	26.52
6.3	98.19	26.89	101.26	26.27	104.33	25.98	107.41	26.04	110.48	26.45
6.4	99.56	26.89	102.63	26.25	105.70	25.95	108.78	25.99	111.85	26.39
6.5	100.93	26.90	104.00	26.24	107.07	25.92	110.14	25.95	113.22	26.33
6.6	102.29	26.91	105.37	26.23	108.44	25.90	111.51	25.91	114.58	26.27
6.7	103.66	26.92	106.74	26.23	109.81	25.87	112.88	25.87	115.95	26.21
6.8	105.03	26.94	108.10	26.23	111.18	25.86	114.25	25.83	117.32	26.16
6.9	106.40	26.95	109.47	26.23	112.54	25.84	115.62	25.80	118.69	26.11
7.0	107.77	26.98	110.84	26.24	113.91	25.83	116.98	25.77	120.06	26.07
7.1	109.14	27.00	112.21	26.24	115.28	25.82	118.35	25.74	121.43	26.02
7.2	110.50	27.03	113.58	26.25	116.65	25.81	119.72	25.72	122.79	25.98
7.3	111.87	27.06	114.95	26.27	118.02	25.81	121.09	25.70	124.16	25.94
7.4	113.24	27.09	116.31	26.28	119.39	25.81	122.46	25.68	125.53	25.91
7.5	114.61	27.12	117.68	26.30	120.75	25.81	123.83	25.67	126.90	25.88
7.6	115.98	27.16	119.05	26.33	122.12	25.82	125.19	25.66	128.27	25.85
7.7	117.35	27.20	120.42	26.35	123.49	25.83	126.56	25.65	129.63	25.82
7.8	118.71	27.25	121.79	26.38	124.86	25.84	127.93	25.64	131.00	25.80
7.9	120.08	27.30	123.15	26.41	126.23	25.85	129.30	25.64	132.37	25.78
8.0	121.45	27.35	124.52	26.45	127.60	25.87	130.67	25.64	133.74	25.77
8.1	122.82	27.40	125.89	26.49	128.96	25.89	132.04	25.65	135.11	25.75
8.2	124.19	27.45	127.26	26.53	130.33	25.92	133.40	25.65	136.48	25.74
8.3	125.56	27.51	128.63	26.57	131.70	25.95	134.77	25.66	137.84	25.73
8.4	126.92	27.57	130.00	26.62	133.07	25.98	136.14	25.68	139.21	25.73
8.5	128.29	27.64	131.36	26.67	134.44	26.01	137.51	25.69	140.58	25.73
8.6	129.66	27.70	132.73	26.72	135.80	26.05	138.88	25.71	141.95	25.73
8.7	131.03	27.77	134.10	26.77	137.17	26.08	140.25	25.74	143.32	25.74
8.8	132.40	27.84	135.47	26.83	138.54	26.13	141.61	25.76	144.69	25.75
8.9	133.76	27.92	136.84	26.89	139.91	26.17	142.98	25.79	146.05	25.76
9.0	135.13	28.00	138.21	26.95	141.28	26.22	144.35	25.82	147.42	25.77
9.1	136.50	28.07	139.57	27.02	142.65	26.27	145.72	25.86	148.79	25.79
9.2	137.87	28.16	140.94	27.09	144.01	26.33	147.09	25.89	150.16	25.81
9.3	139.24	28.24	142.31	27.16	145.38	26.38	148.45	25.93	151.53	25.83
9.4	140.61	28.33	143.68	27.24	146.75	26.44	149.82	25.98	152.90	25.86
9.5	141.97	28.42	145.05	27.31	148.12	26.50	151.19	26.02	154.26	25.89
9.6	143.34	28.51	146.42	27.39	149.49	26.57	152.56	26.07	155.63	25.92
9.7	144.71	28.61	147.78	27.47	150.86	26.64	153.93	26.13	157.00	25.96
9.8	146.08	28.70	149.15	27.56	152.22	26.71	155.30	26.18	158.37	26.00
9.9	147.45	28.80	150.52	27.65	153.59	26.78	156.66	26.24	159.74	26.04
10.0	148.82	28.90	151.89	27.74	154.96	26.86	158.03	26.30	'161.10	26.08

'AND ORD 9

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 5 CSCN = Y = -45.296 + 18.664X1 + 2.216X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	75.55	32.01	77.77	31.55	79.98	31.38	82.20	31.52	84.42	31.96
6.2	79.29	31.94	81.50	31.46	83.72	31.27	85.93	31.39	88.15	31.81
6.4	83.02	31.88	85.23	31.38	87.45	31.18	89.67	31.28	91.88	31.68
6.6	86.75	31.83	88.97	31.31	91.18	31.09	93.40	31.17	95.61	31.55
6.8	90.48	31.80	92.70	31.25	94.92	31.01	97.13	31.07	99.35	31.44
7.0	94.22	31.77	96.43	31.21	98.65	30.95	100.86	30.99	103.08	31.33
7.1	96.08	31.76	98.30	31.19	100.52	30.92	102.73	30.95	104.95	31.29
7.2	97.95	31.75	100.17	31.17	102.38	30.89	104.60	30.91	106.81	31.24
7.3	99.82	31.75	102.03	31.16	104.25	30.87	106.46	30.88	108.68	31.20
7.4	101.68	31.75	103.90	31.15	106.11	30.85	108.33	30.85	110.55	31.16
7.5	103.55	31.75	105.77	31.14	107.98	30.83	110.20	30.82	112.41	31.12
7.6	105.42	31.75	107.63	31.13	109.85	30.81	112.06	30.79	114.28	31.08
7.7	107.28	31.76	109.50	31.13	111.71	30.80	113.93	30.77	116.14	31.05
7.8	109.15	31.77	111.36	31.13	113.58	30.79	115.80	30.75	118.01	31.02
7.9	111.02	31.78	113.23	31.13	115.45	30.78	117.66	30.73	119.88	30.99
8.0	112.88	31.79	115.10	31.14	117.31	30.78	119.53	30.72	121.74	30.97
8.1	114.75	31.81	116.96	31.14	119.18	30.77	121.40	30.71	123.61	30.95
8.2	116.61	31.83	118.83	31.16	121.05	30.77	123.26	30.70	125.48	30.93
8.3	118.48	31.85	120.70	31.17	122.91	30.78	125.13	30.69	127.34	30.91
8.4	120.35	31.88	122.56	31.18	124.78	30.78	126.99	30.69	129.21	30.90
8.5	122.21	31.91	124.43	31.20	126.65	30.79	128.86	30.69	131.08	30.89
8.6	124.08	31.94	126.30	31.22	128.51	30.80	130.73	30.69	132.94	30.88
8.7	125.95	31.97	128.16	31.25	130.38	30.82	132.59	30.69	134.81	30.88
8.8	127.81	32.00	130.03	31.27	132.24	30.83	134.46	30.70	136.68	30.87
8.9	129.68	32.04	131.90	31.30	134.11	30.85	136.33	30.71	138.54	30.87
9.0	131.55	32.08	133.76	31.33	135.98	30.88	138.19	30.72	140.41	30.88
9.1	133.41	32.13	135.63	31.37	137.84	30.90	140.06	30.74	142.28	30.88
9.2	135.28	32.17	137.49	31.41	139.71	30.93	141.93	30.76	144.14	30.89
9.3	137.15	32.22	139.36	31.45	141.58	30.96	143.79	30.78	146.01	30.90
9.4	139.01	32.27	141.23	31.49	143.44	30.99	145.66	30.80	147.87	30.91
9.5	140.88	32.32	143.09	31.53	145.31	31.03	147.53	30.83	149.74	30.93
9.6	142.74	32.38	144.96	31.58	147.18	31.07	149.39	30.86	151.61	30.95
9.7	144.61	32.44	146.83	31.63	149.04	31.11	151.26	30.89	153.47	30.97
9.8	146.48	32.50	148.69	31.68	150.91	31.15	153.12	30.92	155.34	30.99
9.9	148.34	32.56	150.56	31.74	152.78	31.20	154.99	30.96	157.21	31.02
10.0	150.21	32.63	152.43	31.80	154.64	31.25	156.86	31.00	159.07	31.05
10.1	152.08	32.69	154.29	31.86	156.51	31.30	158.72	31.04	160.94	31.08
10.2	153.94	32.76	156.16	31.92	158.37	31.35	160.59	31.08	162.81	31.12
10.3	155.81	32.84	158.03	31.98	160.24	31.41	162.46	31.13	164.67	31.16
10.4	157.68	32.91	159.89	32.05	162.11	31.47	164.32	31.18	166.54	31.20
10.5	159.54	32.99	161.76	32.12	163.97	31.53	166.19	31.24	168.41	31.24
11.0	168.87	33.41	171.09	32.51	173.31	31.88	175.52	31.54	177.74	31.49
11.5								ORD 9 =	189.29	32.02

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 6 CSCN = Y = -26.144 + 9.772X1 + 3.097X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	44.87	36.22	47.97	32.95	51.07	31.67	54.16	32.62	57.26	35.62
6.2	46.83	36.09	49.93	32.64	53.02	31.17	56.12	31.97	59.22	34.87
6.4	48.78	35.99	51.88	32.36	54.98	30.72	58.07	31.36	61.17	34.16
6.6	50.74	35.93	53.83	32.13	56.93	30.30	60.03	30.77	63.12	33.46
6.8	52.69	35.91	55.79	31.94	58.89	29.92	61.98	30.23	65.08	32.80
7.0	54.65	35.92	57.74	31.80	60.84	29.58	63.94	29.71	67.03	32.16
7.1	55.62	35.95	58.72	31.74	61.82	29.43	64.91	29.47	68.01	31.86
7.2	56.60	35.98	59.70	31.69	62.79	29.29	65.89	29.24	68.99	31.56
7.3	57.58	36.02	60.68	31.66	63.77	29.16	66.87	29.02	69.96	31.27
7.4	58.56	36.08	61.65	31.63	64.75	29.04	67.85	28.81	70.94	30.99
7.5	59.53	36.14	62.63	31.62	65.73	28.94	68.82	28.61	71.92	30.72
7.6	60.51	36.21	63.61	31.62	66.70	28.84	69.80	28.42	72.90	30.45
7.7	61.49	36.29	64.58	31.63	67.68	28.76	70.78	28.24	73.87	30.20
7.8	62.46	36.38	65.56	31.65	68.66	28.69	71.75	28.08	74.85	29.96
7.9	63.44	36.48	66.54	31.68	69.63	28.63	72.73	27.92	75.83	29.72
8.0	64.42	36.59	67.52	31.72	70.61	28.58	73.71	27.78	76.81	29.50
8.1	65.40	36.71	68.49	31.77	71.59	28.55	74.69	27.65	77.78	29.28
8.2	66.37	36.83	69.47	31.83	72.57	28.53	75.66	27.53	78.76	29.08
8.3	67.35	36.97	70.45	31.91	73.54	28.52	76.64	27.42	79.74	28.88
8.4	68.33	37.12	71.42	31.99	74.52	28.52	77.62	27.33	80.71	28.70
8.5	69.30	37.27	72.40	32.09	75.50	28.53	78.59	27.24	81.69	28.53
8.6	70.28	37.43	73.38	32.20	76.48	28.56	79.57	27.17	82.67	28.37
8.7	71.26	37.60	74.36	32.31	77.45	28.60	80.55	27.12	83.65	28.22
8.8	72.24	37.78	75.33	32.44	78.43	28.65	81.53	27.07	84.62	28.08
8.9	73.21	37.97	76.31	32.58	79.41	28.71	82.50	27.04	85.60	27.96
9.0	74.19	38.17	77.29	32.72	80.38	28.79	83.48	27.02	86.58	27.84
9.1	75.17	38.37	78.26	32.88	81.36	28.87	84.46	27.02	87.55	27.74
9.2	76.15	38.58	79.24	33.05	82.34	28.97	85.44	27.02	88.53	27.65
9.3	77.12	38.80	80.22	33.23	83.32	29.08	86.41	27.04	89.51	27.58
9.4	78.10	39.03	81.20	33.41	84.29	29.20	87.39	27.08	90.49	27.51
9.5	79.08	39.27	82.17	33.61	85.27	29.34	88.37	27.12	91.46	27.46
9.6	80.05	39.51	83.15	33.81	86.25	29.48	89.34	27.18	92.44	27.42
9.7	81.03	39.76	84.13	34.03	87.22	29.64	90.32	27.25	93.42	27.40
9.8	82.01	40.02	85.11	34.25	88.20	29.80	91.30	27.33	94.40	27.38
9.9	82.99	40.28	86.08	34.48	89.18	29.98	92.28	27.43	95.37	27.38
10.0	83.96	40.55	87.06	34.72	90.16	30.17	93.25	27.54	96.35	27.39
10.1	84.94	40.83	88.04	34.97	91.13	30.37	94.23	27.66	97.33	27.42
10.2	85.92	41.11	89.01	35.22	92.11	30.57	95.21	27.79	98.30	27.45
10.3	86.89	41.41	89.99	35.49	93.09	30.79	96.18	27.94	99.28	27.50
10.4	87.87	41.70	90.97	35.76	94.07	31.02	97.16	28.09	100.26	27.57
10.5	88.85	42.01	91.95	36.04	95.04	31.26	98.14	28.26	101.24	27.64
11.0	93.74	43.61	96.83	37.55	99.93	32.58	103.02	29.26	106.12	28.20
11.5								ORD 9 =	114.10	29.99

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 7 CSCN = Y = -33.188 + 10.432X1 + 6.256X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	54.42	28.02	60.68	26.91	66.94	26.29	73.19	26.21	79.45	26.66
6.2	56.51	27.91	62.77	26.77	69.02	26.12	75.28	26.01	81.53	26.43
6.4	58.60	27.81	64.85	26.64	71.11	25.96	77.36	25.82	83.62	26.22
6.6	60.68	27.73	66.94	26.52	73.20	25.82	79.45	25.64	85.71	26.02
6.8	62.77	27.66	69.03	26.42	75.28	25.68	81.54	25.48	87.79	25.83
7.0	64.86	27.60	71.11	26.33	77.37	25.56	83.62	25.33	89.88	25.65
7.1	65.90	27.57	72.16	26.29	78.41	25.50	84.67	25.26	90.92	25.56
7.2	66.94	27.55	73.20	26.25	79.45	25.45	85.71	25.19	91.97	25.48
7.3	67.99	27.53	74.24	26.22	80.50	25.40	86.75	25.12	93.01	25.40
7.4	69.03	27.51	75.28	26.19	81.54	25.35	87.80	25.06	94.05	25.33
7.5	70.07	27.50	76.33	26.16	82.58	25.31	88.84	25.00	95.09	25.25
7.6	71.12	27.49	77.37	26.13	83.63	25.27	89.88	24.95	96.14	25.18
7.7	72.16	27.48	78.41	26.11	84.67	25.23	90.93	24.89	97.18	25.12
7.8	73.20	27.48	79.46	26.09	85.71	25.20	91.97	24.84	98.22	25.05
7.9	74.24	27.48	80.50	26.08	86.76	25.17	93.01	24.80	99.27	24.99
8.0	75.29	27.48	81.54	26.07	87.80	25.14	94.06	24.76	100.31	24.94
8.1	76.33	27.49	82.59	26.06	88.84	25.12	95.10	24.72	101.35	24.88
8.2	77.37	27.49	83.63	26.05	89.89	25.10	96.14	24.68	102.40	24.83
8.3	78.42	27.50	84.67	26.05	90.93	25.08	97.18	24.65	103.44	24.79
8.4	79.46	27.52	85.72	26.05	91.97	25.07	98.23	24.62	104.48	24.74
8.5	80.50	27.54	86.76	26.06	93.02	25.05	99.27	24.59	105.53	24.70
8.6	81.55	27.56	87.80	26.06	94.06	25.05	100.31	24.57	106.57	24.66
8.7	82.59	27.58	88.85	26.07	95.10	25.04	101.36	24.55	107.61	24.63
8.8	83.63	27.61	89.89	26.09	96.14	25.04	102.40	24.54	108.66	24.60
8.9	84.68	27.64	90.93	26.10	97.19	25.05	103.44	24.53	109.70	24.57
9.0	85.72	27.67	91.98	26.12	98.23	25.05	104.49	24.52	110.74	24.55
9.1	86.76	27.70	93.02	26.15	99.27	25.06	105.53	24.51	111.79	24.53
9.2	87.81	27.74	94.06	26.17	100.32	25.08	106.57	24.51	112.83	24.51
9.3	88.85	27.78	95.10	26.20	101.36	25.09	107.62	24.51	113.87	24.50
9.4	89.89	27.83	96.15	26.24	102.40	25.11	108.66	24.52	114.92	24.49
9.5	90.94	27.87	97.19	26.27	103.45	25.13	109.70	24.53	115.96	24.48
9.6	91.98	27.93	98.23	26.31	104.49	25.16	110.75	24.54	117.00	24.48
9.7	93.02	27.98	99.28	26.35	105.53	25.19	111.79	24.55	118.04	24.48
9.8	94.07	28.03	100.32	26.40	106.58	25.22	112.83	24.57	119.09	24.48
9.9	95.11	28.09	101.36	26.45	107.62	25.26	113.88	24.59	120.13	24.49
10.0	96.15	28.15	102.41	26.50	108.66	25.30	114.92	24.62	121.17	24.50
10.1	97.19	28.22	103.45	26.56	109.71	25.34	115.96	24.65	122.22	24.52
10.2	98.24	28.29	104.49	26.61	110.75	25.39	117.00	24.68	123.26	24.53
10.3	99.28	28.36	105.54	26.67	111.79	25.44	118.05	24.72	124.30	24.56
10.4	100.32	28.43	106.58	26.74	112.84	25.49	119.09	24.76	125.35	24.58
10.5	101.37	28.51	107.62	26.80	113.88	25.55	120.13	24.80	126.39	24.61
11.0	106.58	28.93	112.84	27.18	119.09	25.87	125.35	25.06	131.61	24.80
11.5								ORD 9 =	143.08	25.30

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 8 CSCN = Y = -44.458 + 8.960X1 + 3.352X2

X1 = RH3	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
4.0	4.79	24.69	8.14	23.36	11.49	22.89	14.85	23.33	18.20	24.64
5.0	13.75	23.04	17.10	21.29	20.46	20.45	23.81	20.62	27.16	21.79
5.5	18.23	22.42	21.58	20.45	24.94	19.40	28.29	19.41	31.64	20.48
6.0	22.71	21.94	26.06	19.76	29.42	18.48	32.77	18.31	36.12	19.27
6.2	24.50	21.80	27.86	19.53	31.21	18.16	34.56	17.91	37.91	18.82
6.3	25.40	21.73	28.75	19.42	32.10	18.01	35.46	17.72	38.81	18.61
6.4	26.30	21.68	29.65	19.32	33.00	17.87	36.35	17.54	39.70	18.39
6.5	27.19	21.63	30.54	19.23	33.90	17.74	37.25	17.36	40.60	18.19
6.6	28.09	21.58	31.44	19.15	34.79	17.61	38.14	17.19	41.50	17.99
6.7	28.98	21.55	32.34	19.07	35.69	17.49	39.04	17.03	42.39	17.79
6.8	29.88	21.52	33.23	19.01	36.58	17.37	39.94	16.87	43.29	17.61
6.9	30.78	21.50	34.13	18.95	37.48	17.27	40.83	16.72	44.18	17.43
7.0	31.67	21.48	35.02	18.89	38.38	17.17	41.73	16.58	45.08	17.25
7.1	32.57	21.47	35.92	18.85	39.27	17.08	42.62	16.45	45.98	17.08
7.2	33.46	21.47	36.82	18.81	40.17	17.00	43.52	16.32	46.87	16.92
7.3	34.36	21.47	37.71	18.78	41.06	16.92	44.42	16.21	47.77	16.77
7.4	35.26	21.49	38.61	18.75	41.96	16.86	45.31	16.10	48.66	16.62
7.5	36.15	21.50	39.50	18.74	42.86	16.80	46.21	15.99	49.56	16.48
7.6	37.05	21.53	40.40	18.73	43.75	16.75	47.10	15.90	50.46	16.35
7.7	37.94	21.56	41.30	18.73	44.65	16.72	48.00	15.82	51.35	16.23
7.8	38.84	21.60	42.19	18.74	45.54	16.69	48.90	15.74	52.25	16.12
7.9	39.74	21.65	43.09	18.76	46.44	16.66	49.79	15.68	53.14	16.01
8.0	40.63	21.70	43.98	18.78	47.34	16.65	50.69	15.62	54.04	15.91
8.1	41.53	21.76	44.88	18.82	48.23	16.65	51.58	15.57	54.94	15.82
8.2	42.42	21.82	45.78	18.86	49.13	16.65	52.48	15.54	55.83	15.74
8.3	43.32	21.89	46.67	18.90	50.02	16.67	53.38	15.51	56.73	15.67
8.4	44.22	21.97	47.57	18.96	50.92	16.69	54.27	15.49	57.62	15.61
8.5	45.11	22.06	48.46	19.02	51.82	16.72	55.17	15.48	58.52	15.56
8.6	46.01	22.15	49.36	19.09	52.71	16.76	56.06	15.48	59.42	15.51
8.7	46.90	22.25	50.26	19.17	53.61	16.81	56.96	15.49	60.31	15.48
8.8	47.80	22.35	51.15	19.26	54.50	16.86	57.86	15.51	61.21	15.45
8.9	48.70	22.46	52.05	19.35	55.40	16.93	58.75	15.53	62.10	15.44
9.0	49.59	22.57	52.94	19.45	56.30	17.00	59.65	15.57	63.00	15.43
9.1	50.49	22.70	53.84	19.55	57.19	17.09	60.54	15.62	63.90	15.44
9.2	51.38	22.82	54.74	19.67	58.09	17.18	61.44	15.67	64.79	15.45
9.3	52.28	22.96	55.63	19.79	58.98	17.28	62.34	15.74	65.69	15.47
9.4	53.18	23.09	56.53	19.91	59.88	17.38	63.23	15.81	66.58	15.50
9.5	54.07	23.24	57.42	20.05	60.78	17.50	64.13	15.90	67.48	15.55
9.6	54.97	23.39	58.32	20.19	61.67	17.62	65.02	15.99	68.38	15.60
9.7	55.86	23.54	59.22	20.33	62.57	17.75	65.92	16.09	69.27	15.66
9.8	56.76	23.70	60.11	20.49	63.46	17.88	66.82	16.20	70.17	15.73
9.9	57.66	23.87	61.01	20.64	64.36	18.03	67.71	16.32	71.06	15.80
10.0	58.55	24.04	61.90	20.81	65.26	18.18	68.61	16.44	' 71.96	15.89

'AND ORD 9

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 9 CSCN = Y = -77.398 + 13.613X1 + 6.562X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	30.53	28.49	37.09	26.51	43.65	25.44	50.21	25.40	56.78	26.38
6.2	33.25	28.05	39.81	26.00	46.38	24.87	52.94	24.78	59.50	25.75
6.4	35.97	27.65	42.54	25.52	49.10	24.33	55.66	24.19	62.22	25.14
6.6	38.70	27.27	45.26	25.08	51.82	23.81	58.38	23.63	64.94	24.55
6.8	41.42	26.93	47.98	24.66	54.54	23.33	61.11	23.10	67.67	23.99
7.0	44.14	26.62	50.70	24.28	57.27	22.88	63.83	22.59	70.39	23.47
7.1	45.50	26.48	52.06	24.10	58.63	22.67	65.19	22.36	71.75	23.21
7.2	46.86	26.35	53.43	23.93	59.99	22.46	66.55	22.13	73.11	22.97
7.3	48.22	26.22	54.79	23.78	61.35	22.27	67.91	21.91	74.47	22.74
7.4	49.59	26.11	56.15	23.63	62.71	22.09	69.27	21.70	75.84	22.51
7.5	50.95	26.00	57.51	23.49	64.07	21.92	70.63	21.49	77.20	22.29
7.6	52.31	25.91	58.87	23.36	65.43	21.75	72.00	21.30	78.56	22.08
7.7	53.67	25.82	60.23	23.24	66.79	21.60	73.36	21.12	79.92	21.88
7.8	55.03	25.74	61.59	23.13	68.16	21.46	74.72	20.95	81.28	21.69
7.9	56.39	25.68	62.95	23.03	69.52	21.33	76.08	20.79	82.64	21.52
8.0	57.75	25.62	64.32	22.94	70.88	21.21	77.44	20.64	84.00	21.35
8.1	59.11	25.57	65.68	22.87	72.24	21.10	78.80	20.50	85.36	21.19
8.2	60.48	25.53	67.04	22.80	73.60	21.00	80.16	20.38	86.73	21.04
8.3	61.84	25.50	68.40	22.74	74.96	20.91	81.52	20.26	88.09	20.90
8.4	63.20	25.48	69.76	22.70	76.32	20.84	82.89	20.16	89.45	20.78
8.5	64.56	25.47	71.12	22.67	77.68	20.78	84.25	20.07	90.81	20.66
8.6	65.92	25.48	72.48	22.64	79.05	20.73	85.61	19.99	92.17	20.56
8.7	67.28	25.49	73.84	22.63	80.41	20.69	86.97	19.92	93.53	20.47
8.8	68.64	25.51	75.21	22.63	81.77	20.66	88.33	19.87	94.89	20.39
8.9	70.01	25.54	76.57	22.64	83.13	20.65	89.69	19.83	96.25	20.33
9.0	71.37	25.58	77.93	22.66	84.49	20.65	91.05	19.80	97.62	20.27
9.1	72.73	25.63	79.29	22.70	85.85	20.66	92.41	19.78	98.98	20.23
9.2	74.09	25.69	80.65	22.74	87.21	20.68	93.78	19.78	100.34	20.20
9.3	75.45	25.76	82.01	22.79	88.57	20.71	95.14	19.79	101.70	20.18
9.4	76.81	25.83	83.37	22.86	89.94	20.76	96.50	19.81	103.06	20.18
9.5	78.17	25.92	84.74	22.94	91.30	20.82	97.86	19.84	104.42	20.18
9.6	79.53	26.02	86.10	23.02	92.66	20.89	99.22	19.89	105.78	20.20
9.7	80.90	26.13	87.46	23.12	94.02	20.97	100.58	19.95	107.14	20.24
9.8	82.26	26.24	88.82	23.23	95.38	21.06	101.94	20.02	108.51	20.28
9.9	83.62	26.37	90.18	23.35	96.74	21.17	103.30	20.11	109.87	20.34
10.0	84.98	26.50	91.54	23.48	98.10	21.29	104.67	20.20	111.23	20.41
10.1	86.34	26.64	92.90	23.61	99.47	21.41	106.03	20.31	112.59	20.49
10.2	87.70	26.79	94.26	23.76	100.83	21.55	107.39	20.43	113.95	20.58
10.3	89.06	26.95	95.63	23.92	102.19	21.70	108.75	20.56	115.31	20.69
10.4	90.42	27.12	96.99	24.09	103.55	21.86	110.11	20.71	116.67	20.80
10.5	91.79	27.30	98.35	24.26	104.91	22.03	111.47	20.86	118.03	20.93
11.0	98.59	28.30	105.15	25.28	111.72	23.03	118.28	21.79	124.84	21.73
11.5								ORD 9 =	138.21	23.76

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 10 CSCN = Y = -32.009 + 6.836X1 + 8.291X2

X1 = RH1	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
5.0	35.33	32.28	43.63	30.42	51.92	29.65	60.21	30.05	68.50	31.58
5.5	38.75	31.02	47.04	28.92	55.33	27.94	63.63	28.19	71.92	29.65
6.0	42.17	30.04	50.46	27.69	58.75	26.48	67.04	26.57	75.33	27.94
6.5	45.59	29.36	53.88	26.77	62.17	25.33	70.46	25.23	78.75	26.48
7.0	49.01	29.00	57.30	26.19	65.59	24.52	73.88	24.21	82.17	25.33
7.5	52.42	28.97	60.72	25.97	69.01	24.08	77.30	23.57	85.59	24.52
8.0	55.84	29.28	64.13	26.13	72.42	24.05	80.71	23.33	89.01	24.08
8.5	59.26	29.91	67.55	26.65	75.84	24.42	84.13	23.50	92.42	24.05
9.0	62.68	30.84	70.97	27.52	79.26	25.17	87.55	24.08	95.84	24.42
9.5	66.10	32.05	74.39	28.69	82.68	26.27	90.97	25.03	99.26	25.17
10.0	69.51	33.50	77.80	30.15	86.10	27.67	94.39	26.32	102.68	26.27
10.5								ORD 9 =	114.39	28.69

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 11 CSCN = Y = -61.868 + 7.613X1 + 10.068X2

X1 = RH2	X2 = ORD									
	4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	24.08	22.95	34.15	22.15	44.22	22.35	54.29	23.54	64.35	25.57
6.2	25.60	22.74	35.67	21.81	45.74	21.91	55.81	23.02	65.88	25.00
6.4	27.13	22.56	37.19	21.51	47.26	21.50	57.33	22.52	67.40	24.45
6.6	28.65	22.40	38.72	21.24	48.78	21.11	58.85	22.04	68.92	23.91
6.8	30.17	22.28	40.24	21.00	50.31	20.76	60.38	21.59	70.44	23.39
7.0	31.69	22.19	41.76	20.79	51.83	20.43	61.90	21.16	71.97	22.89
7.1	32.45	22.16	42.52	20.70	52.59	20.28	62.66	20.96	72.73	22.65
7.2	33.22	22.14	43.28	20.61	53.35	20.13	63.42	20.76	73.49	22.42
7.3	33.98	22.12	44.05	20.54	54.11	19.99	64.18	20.57	74.25	22.19
7.4	34.74	22.11	44.81	20.47	54.87	19.87	64.94	20.39	75.01	21.96
7.5	35.50	22.12	45.57	20.41	55.64	19.75	65.70	20.21	75.77	21.74
7.6	36.26	22.12	46.33	20.37	56.40	19.64	66.47	20.05	76.53	21.53
7.7	37.02	22.14	47.09	20.33	57.16	19.53	67.23	19.89	77.29	21.33
7.8	37.78	22.17	47.85	20.30	57.92	19.44	67.99	19.73	78.06	21.13
7.9	38.55	22.20	48.61	20.27	58.68	19.36	68.75	19.59	78.82	20.94
8.0	39.31	22.24	49.37	20.26	59.44	19.28	69.51	19.45	79.58	20.75
8.1	40.07	22.29	50.14	20.26	60.20	19.21	70.27	19.33	80.34	20.57
8.2	40.83	22.35	50.90	20.26	60.97	19.16	71.03	19.21	81.10	20.41
8.3	41.59	22.42	51.66	20.28	61.73	19.11	71.79	19.10	81.86	20.24
8.4	42.35	22.49	52.42	20.30	62.49	19.07	72.56	19.00	82.62	20.09
8.5	43.11	22.57	53.18	20.33	63.25	19.04	73.32	18.91	83.39	19.94
8.6	43.87	22.66	53.94	20.37	64.01	19.02	74.08	18.82	84.15	19.80
8.7	44.64	22.76	54.70	20.42	64.77	19.01	74.84	18.75	84.91	19.67
8.8	45.40	22.87	55.46	20.48	65.53	19.01	75.60	18.69	85.67	19.55
8.9	46.16	22.98	56.23	20.55	66.29	19.02	76.36	18.63	86.43	19.44
9.0	46.92	23.10	56.99	20.62	67.06	19.04	77.12	18.59	87.19	19.33
9.1	47.68	23.22	57.75	20.71	67.82	19.07	77.88	18.55	87.95	19.24
9.2	48.44	23.36	58.51	20.80	68.58	19.11	78.65	18.53	88.71	19.15
9.3	49.20	23.50	59.27	20.90	69.34	19.16	79.41	18.51	89.48	19.08
9.4	49.96	23.65	60.03	21.01	70.10	19.22	80.17	18.51	90.24	19.01
9.5	50.73	23.80	60.79	21.13	70.86	19.28	80.93	18.51	91.00	18.95
9.6	51.49	23.96	61.55	21.26	71.62	19.36	81.69	18.53	91.76	18.90
9.7	52.25	24.13	62.32	21.39	72.38	19.44	82.45	18.55	92.52	18.86
9.8	53.01	24.31	63.08	21.53	73.15	19.54	83.21	18.59	93.28	18.83
9.9	53.77	24.49	63.84	21.68	73.91	19.64	83.97	18.63	94.04	18.81
10.0	54.53	24.67	64.60	21.83	74.67	19.75	84.74	18.68	94.80	18.80
10.1	55.29	24.87	65.36	22.00	75.43	19.87	85.50	18.75	95.57	18.80
10.2	56.05	25.06	66.12	22.17	76.19	20.00	86.26	18.82	96.33	18.81
10.3	56.82	25.27	66.88	22.34	76.95	20.14	87.02	18.90	97.09	18.83
10.4	57.58	25.48	67.64	22.53	77.71	20.28	87.78	18.99	97.85	18.86
10.5	58.34	25.69	68.41	22.72	78.47	20.44	88.54	19.09	98.61	18.90
11.0	62.14	26.84	72.21	23.76	82.28	21.31	92.35	19.73	102.42	19.23
11.5								ORD 9 =	116.29	20.14

CONTINUED . . .

APPENDIX 11 CONTINUED

1966 TREE 12 CSCN = Y = -4.290 + 9.054X1 + 2.908X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	61.67	26.82	64.57	26.25	67.48	25.97	70.39	26.01	73.30	26.37
6.2	63.48	26.81	66.38	26.21	69.29	25.91	72.20	25.94	75.11	26.27
6.4	65.29	26.80	68.19	26.18	71.10	25.86	74.01	25.86	76.92	26.18
6.6	67.10	26.79	70.01	26.15	72.91	25.82	75.82	25.80	78.73	26.10
6.8	68.91	26.79	71.82	26.13	74.72	25.78	77.63	25.74	80.54	26.02
7.0	70.72	26.79	73.63	26.12	76.54	25.74	79.44	25.69	82.35	25.95
7.1	71.62	26.80	74.53	26.11	77.44	25.73	80.35	25.66	83.26	25.91
7.2	72.53	26.81	75.44	26.11	78.35	25.72	81.25	25.64	84.16	25.88
7.3	73.44	26.81	76.34	26.11	79.25	25.70	82.16	25.62	85.07	25.85
7.4	74.34	26.82	77.25	26.11	80.16	25.69	83.06	25.60	85.97	25.82
7.5	75.25	26.83	78.15	26.11	81.06	25.69	83.97	25.58	86.88	25.79
7.6	76.15	26.85	79.06	26.11	81.97	25.68	84.88	25.56	87.78	25.76
7.7	77.06	26.86	79.96	26.12	82.87	25.67	85.78	25.55	88.69	25.74
7.8	77.96	26.87	80.87	26.12	83.78	25.67	86.69	25.53	89.59	25.71
7.9	78.87	26.89	81.78	26.13	84.68	25.67	87.59	25.52	90.50	25.69
8.0	79.77	26.91	82.68	26.14	85.59	25.66	88.50	25.51	91.40	25.67
8.1	80.68	26.93	83.59	26.15	86.49	25.67	89.40	25.50	92.31	25.65
8.2	81.58	26.95	84.49	26.16	87.40	25.67	90.31	25.49	93.22	25.63
8.3	82.49	26.97	85.40	26.17	88.31	25.67	91.21	25.48	94.12	25.62
8.4	83.39	26.99	86.30	26.19	89.21	25.67	92.12	25.48	95.03	25.60
8.5	84.30	27.02	87.21	26.20	90.12	25.68	93.02	25.47	95.93	25.59
8.6	85.21	27.04	88.11	26.22	91.02	25.69	93.93	25.47	96.84	25.58
8.7	86.11	27.07	89.02	26.24	91.93	25.70	94.83	25.47	97.74	25.56
8.8	87.02	27.10	89.92	26.26	92.83	25.71	95.74	25.47	98.65	25.56
8.9	87.92	27.13	90.83	26.28	93.74	25.72	96.65	25.47	99.55	25.55
9.0	88.83	27.16	91.73	26.30	94.64	25.74	97.55	25.48	100.46	25.54
9.1	89.73	27.20	92.64	26.33	95.55	25.75	98.46	25.48	101.36	25.54
9.2	90.64	27.23	93.55	26.35	96.45	25.77	99.36	25.49	102.27	25.53
9.3	91.54	27.27	94.45	26.38	97.36	25.79	100.27	25.50	103.18	25.53
9.4	92.45	27.30	95.36	26.41	98.26	25.80	101.17	25.51	104.08	25.53
9.5	93.35	27.34	96.26	26.44	99.17	25.83	102.08	25.52	104.99	25.53
9.6	94.26	27.38	97.17	26.47	100.08	25.85	102.98	25.53	105.89	25.54
9.7	95.16	27.42	98.07	26.51	100.98	25.87	103.89	25.55	106.80	25.54
9.8	96.07	27.47	98.98	26.54	101.89	25.90	104.79	25.56	107.70	25.55
9.9	96.98	27.51	99.88	26.58	102.79	25.93	105.70	25.58	108.61	25.56
10.0	97.88	27.56	100.79	26.61	103.70	25.95	106.60	25.60	109.51	25.56
10.1	98.79	27.60	101.69	26.65	104.60	25.98	107.51	25.62	110.42	25.57
10.2	99.69	27.65	102.60	26.69	105.51	26.02	108.42	25.64	111.32	25.59
10.3	100.60	27.70	103.50	26.73	106.41	26.05	109.32	25.67	112.23	25.60
10.4	101.50	27.75	104.41	26.78	107.32	26.08	110.23	25.69	113.13	25.62
10.5	102.41	27.80	105.32	26.82	108.22	26.12	111.13	25.72	114.04	25.63
11.0	106.93	28.08	109.84	27.06	112.75	26.32	115.66	25.87	118.57	25.74
11.5								ORD 9 =	126.00	26.01

CONTINUED . . .

APPENDIX 11 CONTINUED

1968 TREE 1 CSCN = Y = 5.256 + 4.191X1 + 13.620X2

X1 = RH2	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
6.0	84.88	44.81	98.50	43.20	112.12	43.02	125.74	44.27	139.36	46.85
6.2	85.72	44.32	99.34	42.58	112.96	42.27	126.58	43.42	140.20	45.93
6.4	86.56	43.89	100.18	42.00	113.80	41.57	127.42	42.62	141.04	45.06
6.6	87.40	43.51	101.02	41.48	114.64	40.91	128.26	41.86	141.88	44.23
6.8	88.24	43.18	101.86	41.02	115.48	40.32	129.10	41.15	142.72	43.43
7.0	89.08	42.92	102.70	40.61	116.32	39.77	129.94	40.49	143.56	42.69
7.1	89.49	42.81	103.11	40.43	116.73	39.52	130.35	40.18	143.97	42.33
7.2	89.91	42.71	103.53	40.26	117.15	39.29	130.77	39.88	144.39	41.99
7.3	90.33	42.63	103.95	40.11	117.57	39.07	131.19	39.60	144.81	41.66
7.4	90.75	42.56	104.37	39.98	117.99	38.86	131.61	39.33	145.23	41.34
7.5	91.17	42.51	104.79	39.86	118.41	38.67	132.03	39.08	145.65	41.04
7.6	91.59	42.47	105.21	39.75	118.83	38.50	132.45	38.84	146.07	40.75
7.7	92.01	42.45	105.63	39.66	119.25	38.34	132.87	38.62	146.49	40.47
7.8	92.43	42.44	106.05	39.59	119.67	38.19	133.29	38.41	146.91	40.21
7.9	92.85	42.45	106.47	39.54	120.09	38.07	133.71	38.22	147.33	39.96
8.0	93.27	42.47	106.89	39.50	120.51	37.96	134.13	38.04	147.75	39.73
8.1	93.69	42.51	107.31	39.47	120.93	37.87	134.55	37.88	148.17	39.51
8.2	94.11	42.57	107.73	39.46	121.35	37.79	134.97	37.73	148.58	39.31
8.3	94.52	42.64	108.14	39.47	121.76	37.73	135.38	37.61	149.00	39.12
8.4	94.94	42.72	108.56	39.50	122.18	37.69	135.80	37.50	149.42	38.94
8.5	95.36	42.82	108.98	39.54	122.60	37.66	136.22	37.40	149.84	38.79
8.6	95.78	42.93	109.40	39.60	123.02	37.65	136.64	37.32	150.26	38.64
8.7	96.20	43.06	109.82	39.67	123.44	37.66	137.06	37.26	150.68	38.52
8.8	96.62	43.20	110.24	39.76	123.86	37.69	137.48	37.22	151.10	38.41
8.9	97.04	43.35	110.66	39.86	124.28	37.73	137.90	37.19	151.52	38.32
9.0	97.46	43.53	111.08	39.98	124.70	37.79	138.32	37.18	151.94	38.24
9.1	97.88	43.71	111.50	40.12	125.12	37.87	138.74	37.19	152.36	38.18
9.2	98.30	43.91	111.92	40.27	125.54	37.96	139.16	37.22	152.78	38.14
9.3	98.72	44.12	112.34	40.44	125.96	38.07	139.58	37.26	153.20	38.11
9.4	99.14	44.34	112.75	40.62	126.37	38.19	139.99	37.32	153.61	38.10
9.5	99.55	44.58	113.17	40.82	126.79	38.34	140.41	37.40	154.03	38.11
9.6	99.97	44.83	113.59	41.03	127.21	38.50	140.83	37.49	154.45	38.14
9.7	100.39	45.10	114.01	41.26	127.63	38.67	141.25	37.60	154.87	38.18
9.8	100.81	45.38	114.43	41.50	128.05	38.86	141.67	37.73	155.29	38.23
9.9	101.23	45.66	114.85	41.75	128.47	39.07	142.09	37.87	155.71	38.31
10.0	101.65	45.97	115.27	42.02	128.89	39.29	142.51	38.03	156.13	38.40
10.1	102.07	46.28	115.69	42.30	129.31	39.52	142.93	38.21	156.55	38.51
10.2	102.49	46.60	116.11	42.59	129.73	39.77	143.35	38.40	156.97	38.63
10.3	102.91	46.94	116.53	42.90	130.15	40.04	143.77	38.61	157.39	38.77
10.4	103.33	47.29	116.95	43.22	130.57	40.32	144.19	38.83	157.81	38.93
10.5	103.75	47.65	117.37	43.55	130.99	40.61	144.61	39.07	158.23	39.10
11.0	105.84	49.59	119.46	45.39	133.08	42.27	146.70	40.47	160.32	40.18
11.5								ORD 9 =	176.04	42.53

CONTINUED . . .

APPENDIX 11 CONTINUED

1968 TREE 2 CSCN = Y = -70.827 + 12.003X1 + 6.777X2

X1 = RH2	X2 = ORD 4 Y	4 +-	5 Y	5 +-	6 Y	6 +-	7 Y	7 +-	8 Y	8 +-
6.0	28.30	26.89	35.07	26.67	41.85	26.75	48.63	27.12	55.40	27.77
6.2	30.70	26.79	37.47	26.53	44.25	26.58	51.03	26.92	57.81	27.54
6.4	33.10	26.70	39.88	26.41	46.65	26.42	53.43	26.73	60.21	27.32
6.6	35.50	26.63	42.28	26.31	49.05	26.29	55.83	26.56	62.61	27.12
6.8	37.90	26.58	44.68	26.22	51.45	26.16	58.23	26.40	65.01	26.93
7.0	40.30	26.54	47.08	26.15	53.85	26.05	60.63	26.26	67.41	26.76
7.1	41.50	26.53	48.28	26.11	55.05	26.00	61.83	26.19	68.61	26.67
7.2	42.70	26.52	49.48	26.09	56.25	25.96	63.03	26.13	69.81	26.60
7.3	43.90	26.51	50.68	26.06	57.45	25.92	64.23	26.07	71.01	26.52
7.4	45.10	26.51	51.88	26.04	58.65	25.88	65.43	26.01	72.21	26.45
7.5	46.30	26.51	53.08	26.03	59.86	25.84	66.63	25.96	73.41	26.38
7.6	47.50	26.52	54.28	26.02	61.06	25.81	67.83	25.92	74.61	26.32
7.7	48.70	26.52	55.48	26.01	62.26	25.79	69.03	25.87	75.81	26.26
7.8	49.90	26.54	56.68	26.00	63.46	25.77	70.23	25.83	77.01	26.20
7.9	51.10	26.55	57.88	26.00	64.66	25.75	71.43	25.80	78.21	26.15
8.0	52.30	26.58	59.08	26.01	65.86	25.73	72.63	25.77	79.41	26.10
8.1	53.50	26.60	60.28	26.02	67.06	25.72	73.83	25.74	80.61	26.05
8.2	54.70	26.63	61.48	26.03	68.26	25.72	75.03	25.71	81.81	26.01
8.3	55.90	26.66	62.68	26.04	69.46	25.72	76.23	25.69	83.01	25.98
8.4	57.10	26.70	63.88	26.06	70.66	25.72	77.43	25.68	84.21	25.94
8.5	58.30	26.74	65.08	26.09	71.86	25.72	78.63	25.67	85.41	25.91
8.6	59.50	26.78	66.28	26.11	73.06	25.73	79.84	25.66	86.61	25.89
8.7	60.70	26.83	67.48	26.14	74.26	25.75	81.04	25.65	87.81	25.87
8.8	61.91	26.88	68.68	26.18	75.46	25.77	82.24	25.65	89.01	25.85
8.9	63.11	26.93	69.88	26.22	76.66	25.79	83.44	25.66	90.21	25.84
9.0	64.31	26.99	71.08	26.26	77.86	25.81	84.64	25.67	91.41	25.83
9.1	65.51	27.06	72.28	26.31	79.06	25.84	85.84	25.68	92.61	25.82
9.2	66.71	27.12	73.48	26.36	80.26	25.88	87.04	25.69	93.81	25.82
9.3	67.91	27.19	74.68	26.41	81.46	25.91	88.24	25.71	95.01	25.82
9.4	69.11	27.26	75.88	26.47	82.66	25.96	89.44	25.74	96.21	25.83
9.5	70.31	27.34	77.08	26.53	83.86	26.00	90.64	25.77	97.41	25.84
9.6	71.51	27.42	78.28	26.60	85.06	26.05	91.84	25.80	98.61	25.85
9.7	72.71	27.50	79.48	26.66	86.26	26.10	93.04	25.83	99.82	25.87
9.8	73.91	27.59	80.68	26.74	87.46	26.16	94.24	25.87	101.02	25.89
9.9	75.11	27.68	81.89	26.81	88.66	26.22	95.44	25.92	102.22	25.92
10.0	76.31	27.77	83.09	26.89	89.86	26.28	96.64	25.96	103.42	25.94
10.1	77.51	27.87	84.29	26.98	91.06	26.35	97.84	26.01	104.62	25.98
10.2	78.71	27.97	85.49	27.06	92.26	26.42	99.04	26.07	105.82	26.02
10.3	79.91	28.08	86.69	27.15	93.46	26.50	100.24	26.13	107.02	26.06
10.4	81.11	28.18	87.89	27.25	94.66	26.58	101.44	26.19	108.22	26.10
10.5	82.31	28.29	89.09	27.34	95.86	26.66	102.64	26.26	109.42	26.15
11.0	88.31	28.89	95.09	27.88	101.86	27.12	108.64	26.64	115.42	26.45
11.5								ORD 9 =	128.20	26.86

CONTINUED . . .

APPENDIX 11 CONTINUED

1968 TREE 4 CSCN = Y = -26.795 + 16.634X1

VARIABLE ORD NEGATIVE AND
NON-SIGNIFICANT, THEREFORE
EXCLUDED FROM EQUATION

X1 = RH3	Y	+-
4.0	39.74	37.64
5.0	56.37	34.42
5.5	64.69	33.00
6.0	73.01	31.74
6.2	76.33	31.28
6.3	78.00	31.06
6.4	79.66	30.85
6.5	81.32	30.64
6.6	82.99	30.45
6.7	84.65	30.26
6.8	86.31	30.08
6.9	87.98	29.91
7.0	89.64	29.74
7.1	91.30	29.59
7.2	92.97	29.44
7.3	94.63	29.30
7.4	96.29	29.17
7.5	97.96	29.05
7.6	99.62	28.93
7.7	101.29	28.83
7.8	102.95	28.74
7.9	104.61	28.65
8.0	106.28	28.58
8.1	107.94	28.51
8.2	109.60	28.45
8.3	111.27	28.41
8.4	112.93	28.37
8.5	114.59	28.34
8.6	116.26	28.32
8.7	117.92	28.31
8.8	119.58	28.31
8.9	121.25	28.32
9.0	122.91	28.34
9.1	124.57	28.37
9.2	126.24	28.41
9.3	127.90	28.46
9.4	129.56	28.52
9.5	131.23	28.59
9.6	132.89	28.66
9.7	134.55	28.75
9.8	136.22	28.85
9.9	137.88	28.95
10.0	139.54	29.07

CONTINUED . . .

APPENDIX 11 CONTINUED

1968 TREE 8 CSCN = Y = -85.402 + 12.974X1 + 4.033X2

X1 = RH3	X2 = ORD 4		5		6		7		8	
	Y	+-	Y	+-	Y	+-	Y	+-	Y	+-
4.0	-17.37	44.70	-13.34	42.71	-9.31	42.06	-5.27	42.82	-1.24	44.91
5.0	-4.40	39.26	-0.36	36.43	3.67	35.11	7.70	35.45	11.74	37.41
5.5	2.09	36.89	6.12	33.57	10.16	31.81	14.19	31.88	18.22	33.75
6.0	8.58	34.83	12.61	30.97	16.64	28.70	20.68	28.42	24.71	30.18
6.2	11.17	34.10	15.21	30.01	19.24	27.52	23.27	27.08	27.30	28.78
6.3	12.47	33.76	16.50	29.55	20.54	26.95	24.57	26.42	28.60	28.09
6.4	13.77	33.43	17.80	29.11	21.83	26.39	25.87	25.77	29.90	27.41
6.5	15.06	33.12	19.10	28.68	23.13	25.84	27.16	25.13	31.20	26.73
6.6	16.36	32.83	20.40	28.27	24.43	25.30	28.46	24.50	32.49	26.06
6.7	17.66	32.55	21.69	27.88	25.73	24.78	29.76	23.87	33.79	25.39
6.8	18.96	32.29	22.99	27.50	27.02	24.27	31.06	23.26	35.09	24.74
6.9	20.25	32.05	24.29	27.14	28.32	23.78	32.35	22.66	36.39	24.09
7.0	21.55	31.82	25.58	26.81	29.62	23.31	33.65	22.07	37.68	23.45
7.1	22.85	31.62	26.88	26.49	30.92	22.85	34.95	21.50	38.98	22.83
7.2	24.15	31.43	28.18	26.19	32.21	22.42	36.25	20.94	40.28	22.21
7.3	25.44	31.27	29.48	25.91	33.51	22.00	37.54	20.40	41.58	21.61
7.4	26.74	31.12	30.77	25.66	34.81	21.61	38.84	19.87	42.87	21.02
7.5	28.04	31.00	32.07	25.43	36.11	21.24	40.14	19.36	44.17	20.44
7.6	29.34	30.89	33.37	25.22	37.40	20.90	41.44	18.88	45.47	19.88
7.7	30.63	30.80	34.67	25.03	38.70	20.57	42.73	18.41	46.77	19.34
7.8	31.93	30.74	35.96	24.87	40.00	20.28	44.03	17.97	48.06	18.81
7.9	33.23	30.70	37.26	24.74	41.30	20.01	45.33	17.56	49.36	18.30
8.0	34.53	30.67	38.56	24.63	42.59	19.78	46.63	17.17	50.66	17.82
8.1	35.82	30.67	39.86	24.54	43.89	19.57	47.92	16.81	51.96	17.36
8.2	37.12	30.69	41.15	24.48	45.19	19.39	49.22	16.48	53.25	16.93
8.3	38.42	30.73	42.45	24.45	46.48	19.25	50.52	16.19	54.55	16.52
8.4	39.72	30.79	43.75	24.44	47.78	19.13	51.82	15.93	55.85	16.14
8.5	41.01	30.87	45.05	24.46	49.08	19.05	53.11	15.71	57.15	15.79
8.6	42.31	30.97	46.34	24.51	50.38	19.01	54.41	15.52	58.44	15.48
8.7	43.61	31.09	47.64	24.58	51.67	19.00	55.71	15.38	59.74	15.20
8.8	44.91	31.23	48.94	24.68	52.97	19.02	57.01	15.27	61.04	14.96
8.9	46.20	31.39	50.24	24.80	54.27	19.07	58.30	15.21	62.34	14.76
9.0	47.50	31.58	51.53	24.95	55.57	19.16	59.60	15.19	63.63	14.61
9.1	48.80	31.78	52.83	25.12	56.86	19.28	60.90	15.21	64.93	14.49
9.2	50.10	31.99	54.13	25.32	58.16	19.43	62.19	15.27	66.23	14.42
9.3	51.39	32.23	55.43	25.54	59.46	19.62	63.49	15.38	67.53	14.39
9.4	52.69	32.49	56.72	25.79	60.76	19.83	64.79	15.52	68.82	14.41
9.5	53.99	32.76	58.02	26.05	62.05	20.08	66.09	15.71	70.12	14.47
9.6	55.29	33.05	59.32	26.34	63.35	20.35	67.38	15.93	71.42	14.57
9.7	56.58	33.36	60.62	26.65	64.65	20.65	68.68	16.19	72.72	14.72
9.8	57.88	33.68	61.91	26.98	65.95	20.98	69.98	16.48	74.01	14.91
9.9	59.18	34.02	63.21	27.33	67.24	21.33	71.28	16.81	75.31	15.14
10.0	60.48	34.37	64.51	27.69	68.54	21.71	72.57	17.17	' 76.61	15.41

'AND ORD 9

APPENDIX 12. SEED PRODUCTION BY SHOOT ORDERS IN WHORLS AND INTERNODES FOR TWELVE TREES IN THREE SEED YEARS

Position on tree (whorl or internode)	1964 Shoot order							1966 Shoot order							1968 Shoot order						
	9	8	7	6	5	4	Total	9	8	7	6	5	4	Total	9	8	7	6	5	4	Total
Tree No. 1																					
W-I		2933					2933		2980					2980		1924					1924
I-I		10379					10379		4303					4303		4074					4074
W-II		2566	17191				19757		5526	14730				20256		2810	8836				11646
I-II		9288	9367				18595		11442	17963				29405		7913	8063				15976
W-III		1759	18473	26830			47062		5092	17207	37967			60266		3647	11619	19703			34969
I-III		392	392				784		2145	5506	3943			11594		1787	3521	733			6041
W-IV		550	2749	2565			5864		1035	4812	10010	4494		20351		2364	9925	9640	6840		28769
I-IV																					
W-V										866	2380	360		3606		1436	3638	3024	1438		9536
I-V																					
W-Total		7808	38413	29395			75616		14633	37615	50357	4854		107459		12181	34018	32367	8278		86844
I-Total		19999	9759				29758		17890	23469	3943			45302		13774	11584	733			26091
TOTAL		27807	48172	29395			105374		32523	61084	54300	4854		152761		25955	45602	33100	8278		112935
Tree No. 2																					
W-I		2864					2864		3309					3309		2308					2308
I-I		4736					4736		4271					4271		5627					5627
W-II		1761	7024				8785		3746	11201				14947		1241	4252				5493
I-II		4363	6040				10403		6457	10762				17219		2949	5657				8606
W-III		1026	2487	839			4352		2248	5274	7640			15162		1097	4232	6540			11869
I-III		315	424				739		3477	3907	4063			11447		1275	3703	2179			7157
W-IV		293	1046	806			2145		753	897	5280	3226		10156		1112	1888	790	1772		5562
I-IV									1088	520	492			2100			133				133
W-V									689	653	463	145		1950			242	108			350
I-V																					
W-Total		5944	10557	1645			18146		10745	18025	13383	3371		45524		5758	10614	7438	1772		25582
I-Total		9414	6464				15878		15293	15189	4555			35037		9851	9493	2179			21523
TOTAL		15358	17021	1645			34024		26038	33214	17938	3371		80561		15609	20107	9617	1772		47105
Tree No. 3																					
W-I		558					558	847	1302					2149	Data too few						
I-I		4599					4599		2238					2238							
W-II		250	5822				6072		2218	2071				4289							
I-II		925	655				1580		4201	3711				7912							
W-III		1106	3263	2052			6421		1629	3893	10198			15720							
I-III		402	373				775		2437	2890	5700			11027							
W-IV		577	1400	1734			3711		1313	810	5212	7132		14467							
I-IV		344	155				499		636	196		326		1158							
W-V									410		517	1092	140	2159							
I-V																					
W-Total		2491	10485	3786			16762	847	6872	6774	15927	8224	140	38784							
I-Total		6270	1183				7453		9512	6797	5700	326		22335							
TOTAL		8761	11668	3786			24215	847	16384	13571	21627	8550	140	61119							

Continued . . .

Appendix 12. Continued

Position on tree (whorl or internode)	1964 Shoot order 9	8	7	6	5	4	Total	1966 Shoot order 9	8	7	6	5	4	Total	1968 Shoot order 9	8	7	6	5	4	Total
<u>Tree No. 4</u>																					
W-I	2539	2049					4584	2627	3222					5849	279	2233					2512
I-I		6925					6925		2201					2201		4004					4004
W-II		2139	5722				7861		1769	2887				4656		1721	5408				7129
I-II		3928	5967				9895		1714	2238				3952		1621	2538				4159
W-III		1098	3234	4614			8946		1872	3136	4594			9602		850	213				1063
I-III		821	1877	348			3046		7653	9789	15715			33157		416	402				818
W-IV		605	3130	5331			9066		1201	1872	5240	8424		16737		359	717	717			1793
I-IV									461		208	202		871							
W-V		735	2824	4309			7868				200	389		589							
I-V		337					337														
W-VI		331	296	392			1019		185					185							
I-VI																					
W-Total	2539	6953	15206	14646			39344	2627	8249	7895	10034	8813		37618	279	5163	6338	717			12497
I-Total		12011	7844	348			20203		12029	12027	15923	202		40181		6041	2940				8981
TOTAL	2539	18964	23050	14994			59547	2627	20278	19922	25957	9051		77799	279	11204	9278	717			21478
<u>Tree No. 5</u>																					
W-I		852					852								Data too few and crown abnormal						
I-I		11101					11101														
W-II		1500	16755				18255		318	8784				9102							
I-II		11687	14523				26210		5377	8467				13844							
W-III		2163	14926	22281			39370		2247	8568	25564			36379							
I-III		1753	5657	2373			9783		7518	7761	14654			29933							
W-IV		182	2556	1643	1095		5476		1217	1434	14312	22790		39753							
I-IV		490					490		667	1094	2561	1889		6211							
W-V			298				298		618	807	10654	7522		19601							
I-V			128				128			183	175			358							
W-VI											160			160							
I-VI																					
W-Total		4697	34535	23924	1095		64251		4400	19593	50690	30312		104995							
I-Total		25031	20308	2373			47712		13562	17505	17390	1889		50346							
TOTAL		29728	54843	26297	1095		111962		17962	37098	68080	32201		155341							
<u>Tree No. 6</u>																					
W-I								228	2971					3199	Data too few						
I-I									4507					4507							
W-II		196	2751				2947		2505	4662				7167							
I-II		1516	2275				3791		3147	4605				7752							
W-III		183	1096	548			1827		693	1169	1929			3792							
I-III										438				438							
W-IV									461	1032	6072	675		8240							
I-IV									140	134	1361	371		2006							
W-V											122			122							
I-V																					
W-Total		379	3847	548			4774	228	6630	6863	8123	675		22519							
I-Total		1516	2275				3791		7794	5177	1361	371		14703							
TOTAL		1895	6122	548			8565	228	14424	12040	9484	1046		37222							

Continued . . .

Appendix 12. Continued

Position on tree (whorl or internode)	1964							1966							1968						
	Shoot order							Shoot order							Shoot order						
	9	8	7	6	5	4	Total	9	8	7	6	5	4	Total	9	8	7	6	5	4	Total
Tree No. 7																					
W-I	592	3908					4500	1145	2369					3514	Data too few						
I-I		5436					5436		1717					1717							
W-II		3764	8705				12469		3635	5056				8691							
I-II		7903	8592				16495		2685	2788				5473							
W-III		2310	3928	4102			10340		3322	1881	3143			8346							
I-III		182		144			326		401	188	176			765							
W-IV									1404	376	527			2307							
I-IV																					
W-Total	592	9982	12633	4102			27309	1145	10730	7313	3670			22858							
I-Total		13521	8592	144			22257		4803	2976	176			7955							
TOTAL	592	23503	21225	4246			49566	1145	15533	10289	3846			30813							
Tree No. 8																					
W-I		570					570	301	432					733		460					460
I-I		1242					1242		1371					1371		581					581
W-II			459				459		756	1790				2546		636	715				1351
I-II		155	143				298		1901	1691				3592		483	459				942
W-III									216	406	757			1379		101	93				194
I-III									212	199				411							
W-IV									90	167	307			564							
I-IV																					
W-Total		570	459				1029	301	1494	2363	1064			5222		1197	808				2005
I-Total		1397	143				1540		3484	1890				5374		1064	459				1523
TOTAL		1967	602				2569	301	4978	4253	1064			10596		2261	1267				3528
Tree No. 9																					
W-I		861					861								Data too few and crown abnormal						
I-I		2627					2627														
W-II		598	4238				4836		2892	6908				9800							
I-II		910	163				1073		3161	5547				8708							
W-III		1282	3194	613			5089		2733	4370	7435			14538							
I-III		170	466				636		1236	1304	1338			3878							
W-IV			608	137			745		672	155	425			1252							
I-IV																					
W-V																					
I-V																					
W-VI																					
I-VI																					
W-VII										104				104							
I-VII																					
W-Total		2741	8040	750			11531		6297	11537	7860			25694							
I-Total		3707	629				4336		4397	6851	1338			12586							
TOTAL		6448	8669	750			15867		10694	18388	9198			38280							

Continued . . .

Appendix 12. Continued

Position on tree (whorl or internode)	1964							1966							1968						
	Shoot order							Shoot order							Shoot order						
	9	8	7	6	5	4	Total	9	8	7	6	5	4	Total	9	8	7	6	5	4	Total
<u>Tree No. 10</u>																					
W-I		1862					1862								Data too few						
I-I		3771					3771														
W-II		216	3677				3893		383	6479				6862							
I-II		3853	4067				7920		2218	5889				8107							
W-III		1391	4654	711			6756		1068	2098	2317			5483							
I-III		1711	863	93			2667		342					342							
W-IV		182	266	85			533		164	296	656			1116							
I-IV			121				121		158		249			407							
W-V			348				348														
I-V																					
W-Total		3651	8945	796			13392		1615	8873	2973			13461							
I-Total		9335	5051	93			14479		2718	5889	249			8856							
TOTAL		12986	13996	889			27871		4333	14762	3222			22317							
<u>Tree No. 11</u>																					
W-I		Data too few							1434					1434	No cones borne						
I-I									5427					5427							
W-II									2775	13728				16003							
I-II									3354	8683				12037							
W-III									1395	6786	8181			16362							
I-III																					
W-IV									637	834	357			1828							
I-IV																					
W-Total									5741	21348	8538			35627							
I-Total									8781	8683				17464							
TOTAL									14522	30031	8538			53091							
<u>Tree No. 12</u>																					
W-I		Data too few						1260	1423					2683	Data too few						
I-I									2203					2203							
W-II									2628	5756				8384							
I-II									4007	4724				8731							
W-III									2210	4682	11357			18249							
I-III									1676	901	1247			3824							
W-IV									1645	1947	6847	331		10770							
I-IV																					
W-V									824	1271	918	147		3160							
I-V																					
W-VI									293			129		422							
I-VI																					
W-Total								1260	9023	13656	19122	607		43668							
I-Total									7886	5625	1247			14758							
TOTAL								1260	16909	19281	20369	607		58426							

APPENDIX 13. MEAN NUMBERS OF TERMINAL AND OF LATERAL SHOOTS PRODUCED PER SHOOT OF HIGHER ORDER BY WHORL AND BY INTERNODE ON EIGHT TREES IN 1967 AND 1968, AND ON FOUR TREES IN 1969

Whorl:[1]	I			II			II			III			III			III		
Orders:	7 & 8 on 8			7 & 8 on 8			6 on 7			7 & 8 on 8			6 on 7			5 on 6		
Tree	1967	1968	1969	1967	1968	1969	1967	1968	1969	1967	1968	1969	1967	1968	1969	1967	1968	1969
Terminal Shoots																		
1	3.0	3.0	3.0	3.8	3.7	3.0	3.4	2.6	2.9	3.0	3.3	3.0	2.8	2.7	2.7	2.1	2.1	2.1
2	4.0	3.2		3.0	3.0		2.9	2.6		3.3	4.0		3.0	2.1		1.8	1.7	
3	3.0	3.0		3.0	3.0		3.0	1.5		3.0	3.0		2.8	1.7		1.8	1.6	
4	4.0	3.3	3.3	3.0	3.3	3.7	2.4	2.2	2.6	3.0	2.3	3.3	2.5	2.4	2.1	1.4	1.8	1.5
8	3.0	3.0	3.0	2.7	3.0	2.0	2.0	1.8	1.0	3.0	2.5	3.0	1.2	1.8	1.2	1.1	1.5	1.4
11	3.0	3.0		3.0	3.0		2.2	2.4		3.0	3.0		2.0	2.2		1.5	2.1	
12	3.8	3.0	3.0	3.0	3.0	3.0	2.6	2.4	2.8	3.0	3.0	3.0	2.1	2.2	2.8	1.2	1.8	1.7
13	4.7	3.0		3.7	4.0		3.0	2.2		3.0	4.0		2.7	2.0		1.6	2.3	
Lateral Shoots																		
1	4.0	1.7	3.7	3.2	1.7	3.7	0.5	0	0.5	4.0	1.0	3.0	0.4	0	0.5	0.2	0	0.1
2	4.0	1.0		3.0	1.0		0	0		2.3	1.0		0	0.1		0	0	
3	2.3	0.7		3.5	0.7		0.5	0		2.7	0		0.1	0		0	0	
4	2.3	0.3	2.3	1.7	0	1.3	0	0	0	1.0	0.7	0.3	0	0	0	0	0	0
8	1.5	0.5	2.0	0.3	0	1.0	0	0	0	0.3	0	1.0	0	0	0	0	0	0
11	3.0	1.7		2.7	2.8		0.4	0.2		1.5	2.0		0.2	0.1		0	0	
12	1.8	1.0	3.0	3.0	1.2	2.8	0.3	0.2	0.2	1.7	2.0	1.8	0.4	0.3	0	0.2	0	0
13	4.0	3.0		2.7	4.3		0.1	0		1.5	2.3		0	0		0	0	

Internode:[1]	I			II			II			III			III			III		
Orders:	7 & 8 on 8			7 & 8 on 8			6 on 7			7 & 8 on 8			6 on 7			5 on 6		
Terminal Shoots																		
1	3.0	2.8	3.0	3.6	3.0	3.0	2.1	1.9	2.1	2.6	2.7	2.7	2.0	1.8	1.9	1.5	1.4	1.3
2	3.0	2.9		2.9	3.3		2.4	2.6		2.7	3.3		2.2	2.2		1.3	1.6	
3	2.2	1.7		2.7	2.5		1.6	1.5		2.3	1.8		1.5	1.0		1.2	1.2	
4	3.0	2.9	2.8	3.0	3.6	2.9	2.0	2.0	1.3	3.0	3.3	3.0	1.7	1.6	1.9	1.2	1.4	1.3
8	2.7	2.8	2.5	1.8	1.8	2.0	1.0	1.2	1.1	1.5	2.7	3.0	1.0	1.0	1.0	1.0	1.8	1.0
11	2.2	2.3		2.4	2.9		1.8	2.5		2.3	3.0		1.2	2.0		1.0	2.2	
12	2.5	2.6	2.2	2.9	3.0	2.8	1.2	1.3	1.2	1.8	3.0	2.2	1.0	1.2	1.0	1.0	1.3	1.2
13	3.0	2.8		2.8	2.7		2.0	2.1		2.1	2.7		1.1	1.2		1.0	1.4	
Lateral Shoots																		
1	0.3	0	0.3	0	0	0.3	0	0	0	0.2	0.3	0.2	0	0	0	0	0	0
2	0.2	0		1.3	0.3		0	0		0.3	0.7		0	0		0	0	
3	0.2	0		0.2	0		0	0		0.4	0		0	0		0	0	
4	0	0	0.1	1.0	0.2	0	0	0	0	0.7	0	0.2	0	0	0	0	0	0
8	0.7	0	0.5	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0.1	0		0.4	0.5		0	0		0	0.3		0	0		0	0	
12	0.8	0.4	0.5	0.7	0.2	0	0	0	0.4	0.2	0.3	0	0	0	0	0	0	0
13	0.3	0.2		0.3	0.4		0	0		0	0		0	0		0	0	

[1] Whorl and internode numbers are for the year of shoot elongation.

___ 1968 shoots borne on shoots carrying many cones.

_ 1968 shoots borne on shoots carrying few cones.

APPENDIX 14. NUMBERS OF BRANCHES, SHOOTS, NON-BUD-BEARING SHOOTS, AND LATERAL BUDS FORMED, BY WHORL AND INTERNODE, IN THE FEMALE ZONES OF TREES 1, 4, 8 AND 12 IN 1967, 1968 AND 1969, AND OF TREES 2, 3, 10 AND 13 IN 1967 AND 1968

Year	Position in zone	Branches	Shoots	Non-bud-bearing shoots	Vegetative buds	Latent buds	Female buds	Total buds	Shoots with male buds
Tree 1									
1967	L	1	1		10			10	
	W-I	3	3		6	1	6	13	
	I-I	10	10	1	0	0	13	13	
	W-II	3	21	0	5	0	41	46	
	I-II	11	36	0	1	13	55	69	
	W-III	4	86	3	3	26	136	165	
	I-III	8	61	18	2	43	23	68	
	W-IV	4	229	72	14	141	120	275	
	I-IV	18	235	155	3	126	0	129	1
	W-V	5	563	373	17	280	39	336	1
	Total	67	1235	622	61	630	433	1124	2
1968	L	1	1		9			9	
	W-I	3	3		11			11	
	I-I	7	7		4	9		13	
	W-II	3	14		15	15		30	
	I-II	8	22	5	2	22		24	
	W-III	3	60	23	19	45		64	
	I-III	9	44	36	1	10		11	
	W-IV	4	136	83	15	79		94	
	I-IV	8	79	70	1	13		14	
	W-V	4	299	236	8	89		97	
	Total	50	665	453	85	282	0	367	0
1969	L	1	1		14	1		15	
	W-I	3	3		10	0	4	14	
	I-I	9	9		0	0	18	18	
	W-II	3	19		16	1	29	30	
	I-II	7	23		3	13	34	50	
	W-III	3	47	1	12	21	68	101	
	I-III	7	20	2	0	29	1	30	
	W-IV	3	130	15	22	120	39	181	
	I-IV	9	62	34	3	38	0	41	
	W-V	4	242	116	30	170	5	205	
	Total	49	556	168	110	393	198	685	0

Continued . . .

Appendix 14. Continued

Year	Position in zone	Branches	Shoots	Non-bud-bearing shoots	Vege-tative buds	Latent buds	Female buds	Total buds	Shoots with male buds
Tree 2									
1967	L	(1)	(1)		(14)			(14)	
	W-I	(4)	(4)		(5)		(10)	(15)	
	I-I	15	15			2	27	29	
	W-II	2	16	1	4	0	28	32	
	I-II	8	26	0	9	3	49	61	
	W-III	3	61	1	4	30	73	107	
	I-III	8	66	6	7	41	49	97	
	W-IV	4	136	34	7	96	41	144	
	I-IV	12	170	108	7	78	1	86	
	W-V	3	162	91	10	72	3	85	
	Total	56	652	241	48	322	271	641	0
1968	L								
	W-I								
	I-I	8	8		10	6		16	
	W-II	4	16		9	25		34	
	I-II	15	43	1	7	28		35	
	W-III	1	22	13	2	16		18	
	I-III	7	51	38	2	19		21	
	W-IV	2	69	55	1	15		16	
	I-IV	7	111	100	1	21		22	
	W-V	4	167	145	2	30		32	
	Total	48	487	352	34	160	0	194	0

( ) Numbers in brackets not included in totals since no comparable data were available for 1968.

Continued . . .

Appendix 14. Continued

	Position in zone	Branches	Shoots	Non-bud-bearing shoots	Vegetative buds	Latent buds	Female buds	Total buds	Shoots with male buds
Tree 3									
1967	L	1	1		3	2		5	
	W-I	3	3		2	4		6	
	I-I	9	9	5	0	1	3	4	
	W-II	3	16	5	2	1	13	16	
	I-II	4	10	2	1	6	4	11	
	W-III	2	27	7	2	7	18	27	
	I-III	6	35	24	1	7	6	14	
	W-IV	3	77	41	1	19	29	49	
	I-IV	7	48	37	2	6	7	15	
	W-V	3	89	69	3	19	6	28	
	Total	41	315	190	17	72	86	175	0
1968	L	1	1		1	1		2	
	W-I	2	2		0	3		3	
	I-I	2	2	1	0	1		1	
	W-II	3	11	6	0	7		7	
	I-II	9	15	8	0	8		8	
	W-III	3	31	19	0	14		14	
	I-III	4	19	14	0	5		5	
	W-IV	2	47	28	1	22		23	
	I-IV	6	42	40	0	2		2	
	W-V	3	104	87	1	24		25	
	Total	35	274	203	3	87	0	90	0

Continued . . .

Appendix 14. Continued

	Position in zone	Branches	Shoots	Non-bud-bearing shoots	Vegetative buds	Latent buds	Female buds	Total buds	Shoots with male buds
Tree 4									
1967	L	1	1		12		1	13	
	W-I	3	3		1		8	9	
	I-I	8	8		0		15	15	
	W-II	3	19		0	3	29	32	
	I-II	5	15		1	10	18	29	
	W-III	3	31	1	2	46	5	53	
	I-III	3	20	0	0	30	4	34	
	W-IV	3	62	4	2	76	10	88	
	I-IV	3	36	5	0	48	0	48	
	W-V	3	65	23	0	62	0	62	
	Total	35	260	33	18	275	90	383	0
1968	L	1	1		11	1		12	
	W-I	3	3		8	4		12	
	I-I	11	11		0	23		23	
	W-II	3	11		4	17		21	
	I-II	8	23	1	0	37		37	
	W-III	3	44	22	3	33		36	
	I-III	5	39	22	3	28		31	
	W-IV	3	65	38	0	39		39	
	I-IV	3	36	26	0	13		13	
	W-V	3	87	65	1	33		34	
	Total	43	320	174	30	228	0	258	0
1969	L	1	1		12	2	5	19	
	W-I	3	3		6	0	7	13	
	I-I	2	2		0	0	4	4	
	W-II	3	17		1	2	29	32	
	I-II	11	32		0	11	48	59	
	W-III	3	35	2	3	25	34	62	
	I-III	8	42	1	4	46	9	59	
	W-IV	3	74	13	4	71	13	88	
	I-IV	5	63	21	0	51	6	57	
	W-V	3	87	66	1	25	1	27	
	Total	42	356	103	31	233	156	420	0

Continued . . .

Appendix 14. Continued

	Position in zone	Branches	Shoots	Non-bud-bearing shoots	Vegetative buds	Latent buds	Female buds	Total buds	Shoots with male buds
Tree 8									
1967	L	1	1		6			6	
	W-I	2	2		1		3	4	
	I-I	4	5		1	1	4	6	
	W-II	2	9		0	1	12	13	
	I-II	3	10		0	6	8	14	
	W-III	2	12	1	0	11	2	13	
	I-III	6	14	1	0	15	0	15	
	W-IV	3	34	18	4	19	0	23	
	I-IV	7	28	21	0	8	0	8	2
	W-V	2	38	37	1	0	0	1	31
	Total	32	153	78	13	61	29	103	33
1968	L	1	1		7			7	
	W-I	2	2		4			4	
	I-I	7	7		0	9		9	
	W-II	2	7	6	2	0		2	
	I-II	5	13	11	0	2		2	
	W-III	2	16	13	1	3		4	
	I-III	3	13	12	0	1		1	
	W-IV	2	21	20	0	1		1	2
	I-IV	6	23	18	0	7		7	3
	W-V	3	71	66	0	5		5	61
	Total	33	174	146	14	28	0	42	66
1969	L	1	1		5			5	
	W-I	2	2		1		3	4	
	I-I	7	7		2	2	5	9	
	W-II	2	10		5	6	1	12	
	I-II	4	12	4	1	5	4	10	
	W-III	2	11	3	0	9	0	9	
	I-III	5	18	11	2	6	0	8	1
	W-IV	2	18	10	5	8	0	13	8
	I-IV	3	14	9	2	3	0	5	7
	W-V	2	24	21	0	4	0	4	21
	Total	30	117	58	23	43	13	79	37

Continued . . .

Appendix 14. Continued

	Position in zone	Branches	Shoots	Non-bud-bearing shoots	Vegetative buds	Latent buds	Female buds	Total buds	Shoots with male buds
Tree 10									
1967	L	1	1		3			3	
	W-I	3	3		3	2		5	
	I-I	2	2		0	1	1	2	
	W-II	1	4		2	0	4	6	
	I-II	4	9		3	12	3	18	
	W-III	0							
	I-III	0							
	W-IV	(3)	(67)	(11)	(5)	(94)	(1)	(100)	
	I-IV	(9)	(54)	(12)	(8)	(62)	(1)	(71)	
	W-V	5	33	7	9	35	0	44	
	Total	16	52	7	20	50	8	78	0
1968	L	1	1		11			11	
	W-I	2	2		7			7	
	I-I	1	1		1	1		2	
	W-II	3	6	3	0	5		5	
	I-II	2	4		0	7		7	
	W-III	(1)	(8)	(3)	(0)	(8)		(8)	
	I-III	(4)	(28)	(4)	(0)	(39)		(39)	
	W-IV	0							
	I-IV	0							
	W-V	3	166	105	3	71		74	
	Total	12	180	108	22	84	0	106	0

( ) Numbers in brackets not included in totals since no comparable data were available for the other year.

Continued . . .

Appendix 14. Continued

	Position in zone	Branches	Shoots	Non-bud-bearing shoots	Vegetative buds	Latent buds	Female buds	Total buds	Shoots with male buds
Tree 12									
1967	L	1	1		9			9	
	W-I	4	4		5	1	3	9	
	I-I	5	5	1	2	4	0	6	
	W-II	4	21	3	8	14	12	34	
	I-II	4	13	2	1	12	2	15	
	W-III	3	44	9	9	40	5	54	
	I-III	7	40	5	2	41	1	44	
	W-IV	4	87	13	11	89	0	100	
	I-IV	11	51	30	3	22	0	25	
	W-V	4	99	46	11	57	0	68	
	Total	47	365	108	61	280	23	364	0
1968	L	1	1		9			9	
	W-I	4	4		12			12	
	I-I	6	6		3	5		8	
	W-II	4	16		14	21		35	
	I-II	5	15	9	0	11		11	
	W-III	4	56	24	8	50		58	
	I-III	4	25	21	0	8		8	
	W-IV	3	96	66	5	43		48	
	I-IV	7	64	57	0	11		11	
	W-V	4	166	136	3	47		50	
	Total	42	449	313	54	196	0	250	0
1969	L	1	1		7			7	
	W-I	3	3		5		3	8	
	I-I	8	8		4	2	9	15	
	W-II	4	24		17	3	27	47	
	I-II	6	13		0	13	7	20	
	W-III	4	62	2	17	61	18	96	
	I-III	5	23	8	0	15	0	15	
	W-IV	4	91	30	30	60	2	92	
	I-IV	4	24	21	0	3	0	3	1
	W-V	3	117	80	15	42	0	57	10
	Total	42	366	141	95	199	66	360	11

Continued . . .

Appendix 14. Continued

Year	Position in zone	Branches	Shoots	Non-bud-bearing shoots	Vegetative buds	Latent buds	Female buds	Total buds	Shoots with male buds
Tree 13									
1967	L	1	1		9			9	
	W-I	4	4		11		1	12	
	I-I	11	11		1	17	2	20	
	W-II	3	26	1	14	38	3	55	
	I-II	9	30	0	3	58	7	68	
	W-III	3	65	2	7	108	0	115	
	I-III	6	43	6	0	56	0	56	
	W-IV	4	104	17	9	135	0	144	
	I-IV	12	56	37	1	33	0	34	26
	W-V	3	165	112	8	96	0	104	75
	Total	56	505	175	63	541	13	617	101
1968	L	1	1		12			12	
	W-I	3	3		17	1		18	
	I-I	8	8	1	3	10		13	
	W-II	4	22	2	18	34		52	
	I-II	11	32	6	3	42		45	
	W-III	3	75	18	12	85		97	
	I-III	8	67	43	2	40		42	
	W-IV	3	99	34	14	93		107	
	I-IV	6	60	44	0	21		21	15
	W-V	4	169	134	16	55		71	73
	Total	51	536	282	97	381	0	475	88

APPENDIX 15. NUMBER OF SHOOTS, MEAN SHOOT LENGTHS AND MEAN NUMBERS OF TERMINAL AND OF LATERAL BUDS PER SHOOT IN THE UPPER TWO WHORLS IN EACH YEAR FROM 1963 TO 1968 AND IN THE UPPER FOUR WHORLS IN EACH YEAR FROM 1965 TO 1968, ALL ON EACH OF THREE TREES

		No. of shoots [2]		Shoot length (cm)		No. terminal buds		No. lateral buds	
Tree	Year[1]	Two Whorls	Four Whorls	Two Whorls	Four Whorls	Two Whorls	Four Whorls	Two Whorls	Four Whorls
3	1963	22	-	5.64	-	3.04	-	2.09	-
	1964	19	-	5.39	-	3.00	-	1.32	-
	1965	17	170	5.35	3.52	2.71	2.28	1.88	1.08
	1966	9	134	7.03	3.28	3.00	1.78	2.56	0.69
	1967	19	121	3.08	2.34	2.16	1.67	1.16	0.81
	1968	13	91	3.38	3.38	2.23	1.85	0.77	0.52
8	1963	16	-	4.28	-	2.62	-	1.81	-
	1964	11	-	4.32	-	2.64	-	1.36	-
	1965	19	93	3.50	2.54	2.74	1.88	1.26	0.69
	1966	7	70	2.36	1.60	2.43	1.40	1.00	0.39
	1967	11	55	3.26	2.16	2.64	2.29	1.54	0.96
	1968	8	43	2.61	2.02	1.75	1.46	0.75	0.28
11	1963	60	-	5.97	-	2.62	-	2.02	-
	1964	51	-	6.89	-	2.96	-	1.94	-
	1965	53	467	5.87	3.33	3.04	1.87	2.68	0.83
	1966	42	422	3.22	1.95	2.26	1.47	0.95	0.23
	1967	27	339	4.06	2.48	2.67	2.15	1.59	0.66
	1968	16	306	7.20	3.18	3.31	1.78	2.94	1.01

1 Years underlined indicate cone-bearing years for the tree concerned.

2 Shoots which completed development: a few shoots were broken during the course of the study by one of a variety of causes (e.g. snow and ice, wind and towers, handling, squirrels) and thus the numbers do not necessarily indicate the total shoot production.

APPENDIX 16

POSTDORMANCY DEVELOPMENT AND GROWTH OF MICROSPORANGIATE AND MEGASPORANGIATE STROBILI OF *ABIES BALSAMEA*

by

G. R. Powell

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Postdormancy development and growth of microsporangiate and megasporangiate strobili of *Abies balsamea*[1]

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Postdormancy development and growth of strobili of *Abies balsamea* (L.) Mill. are described. Some strobilus growth occurs within the buds before bud swelling becomes detectable. The strobilus buds burst before the vegetative buds. The latter burst about 10 days after the megasporangiate buds, by which time pollen is being shed and the megasporangiate strobili are receptive. Elongation of megasporangiate strobili is divided into two stages; the first, occurring before the strobili are receptive, accompanies the grand period of bract growth; the second accompanies the grand period of ovuliferous-scale growth. The two stages are not evident when growth is expressed as dry weight. Elongation ceases in mid July, but strobilus dry weight increases until mid August. This is largely accounted for by embryo growth in the contained seeds.

The moisture content of microsporangiate strobili reaches a maximum just before pollen release. Pollen grains account for about half the mature strobilus dry weight. The moisture content of megasporangiate strobili reaches a maximum at the time of fertilization, after which it declines until the strobili break up.

Megasporangiate strobili situated in upper positions become larger than those situated lower in the megasporangiate-strobilus bearing zone.

Introduction

Details of parts of the reproductive cycle of various species of the genus *Abies* have been described (Miyake 1903; Hutchinson 1914, 1915; Buchholz 1942; Doyle and Kane 1943; Mergen and Lester 1961; Kantor and Chira 1954; Dogra 1966; Ritchie 1966). However, no account has been given of the complete cycle for any one species. Bakuzis and Hansen (1965) indicated the need for correlative documentation of the gross morphological development of strobili and details of the reproductive cycle in this genus.

Some aspects of development of microsporangiate strobili were described for four *Abies* species by Mergen and Lester (1961). Ritchie (1966) described the growth of microsporangiate and megasporangiate strobili of *A. amabilis* (Dougl.) Forbes and *A. procera* Rehd. Megasporangiate-strobilus growth of *A. sachalinensis* Mast. was described by Matsuura (1961).

In this paper an account will be given of the postdormancy development and growth of strobili of *A. balsamea* (L.) Mill.

Methods and Materials

Developing strobili were studied in two seed years, 1966 and 1968, on 12 trees situated in the University of New Brunswick Forest, Fredericton, New Brunswick. Except where indicated, the procedures adopted in each year were similar.

Six trees were used for *in situ* measurements of megasporangiate-strobilus growth. On each of these, several megasporangiate buds on branches in each bearing whorl, within the megasporangiate-strobilus-bearing zone (Morris 1951), were marked and measured in the fall. The length and diameter of each bud were measured again on one occasion during the winter and again in late March. In mid April, weekly measurements of these buds, and of the strobili developing from them, were started; these continued until late August. Some marked cones were lost during the season as a result of insect and squirrel activity. The series of measurements were completed on 131 cones in 1966 and on 34 in 1968.

The other six trees were used to supply samples of buds and strobili for laboratory analyses. A sample was collected in the fall, another in mid winter, the rest at about weekly intervals from late March to late August. At each collection buds or strobili were removed, as numbers permitted, from each bearing whorl of branches and from each group of bearing internode branches. Representative sampling was easier to achieve in 1966 than in 1968, in which fewer strobili were produced. In 1966 about 60 strobili were taken at each collection, in 1968 only 15.

All the strobili collected (except one or two from each of four trees in 1966, which were fixed on collection) were measured and weighed in the fresh condition. Two strobili from each tree were then set aside for moisture content determinations, the rest were dissected. The ovuliferous scales were removed in sequence and counted. Those from the central region of the strobilus on which normally developing ovules could be seen were counted separately. Measurements of bract and ovuliferous-scale length and breadth were made on each of four bract-scale complexes from comparable positions in each strobilus.

[1]This work was supported in part by National Research Council of Canada Grant No. A1985 and in part by New Brunswick Research and Productivity Council Grant No. G52.

The ovules and seeds borne on each of these scales were examined and details of their development recorded.

The strobili used for moisture content and dry weight determinations were always taken one from an upper whorl, the other from a lower whorl on the trees. The strobili were dried at 105 °C for 24 h in a forced-air oven. During the period of seed maturation, seeds from other cones were dried for 1 h at 105 °C (cf. Magini and Cappelli 1962).

In 1966 some microsporangiate and megasporangiate buds and strobili were killed and fixed in formalin – acetic acid – ethyl alcohol. These were dehydrated in an ethyl alcohol – butyl alcohol series and imbedded in Tissuemat. Serial sections were stained in safranin and fast green.

In the fall of 1967, six microsporangiate buds on each of eight trees were marked and measured. These buds and the strobili developing from them were measured

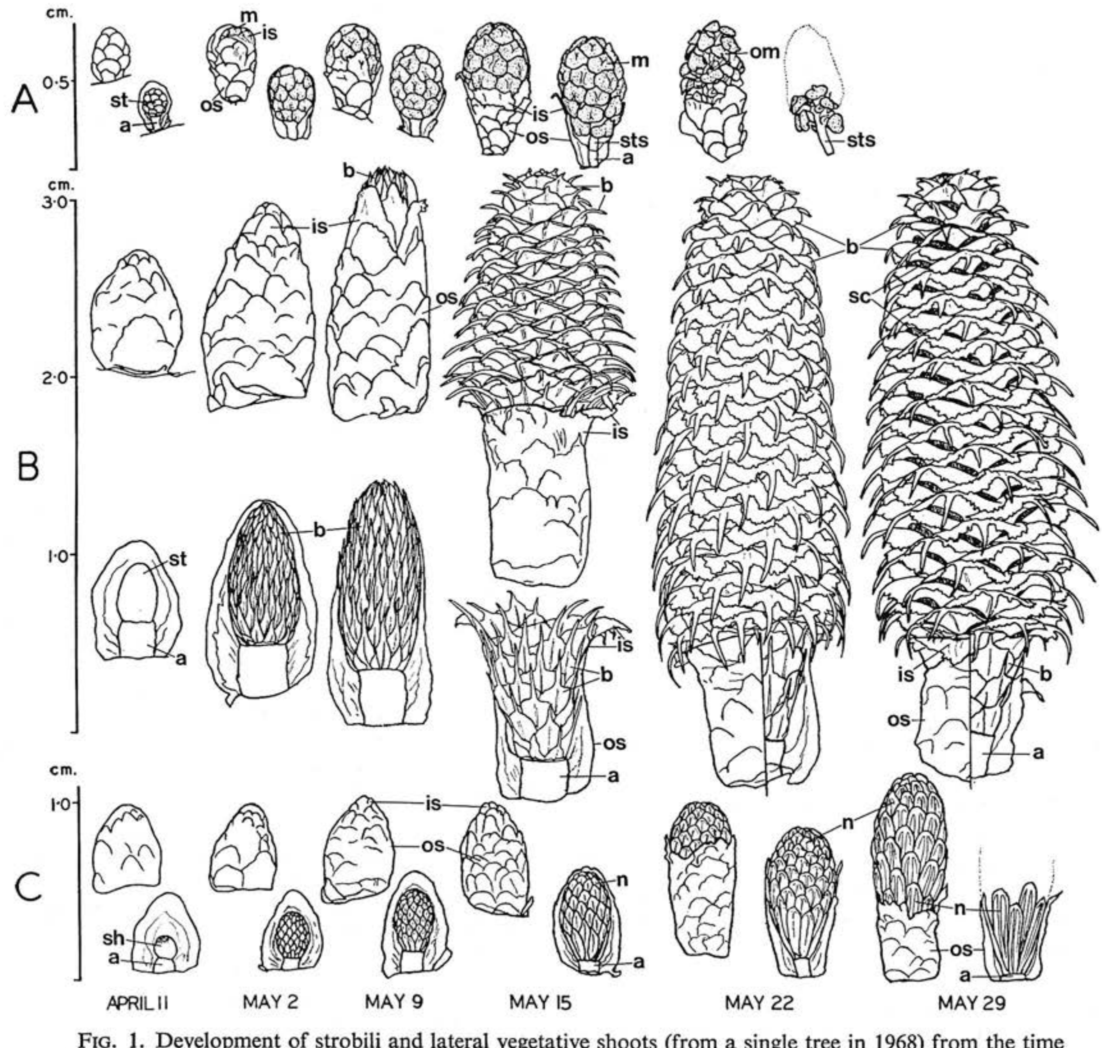

FIG. 1. Development of strobili and lateral vegetative shoots (from a single tree in 1968) from the time of dormancy to the time of termination of the receptive stage in the megasporangiate strobilus. (A) Microsporangiate strobilus: by date, left = entire bud and strobilus, right = bud scales partially removed to show base of strobilus and part of axis (*a*) bearing bud scales, (*is*) inner bud scale, (*os*) outer bud scale, (*m*) microsporophyll, (*om*) open microsporangium, (*st*) strobilus, (*sts*) strobilus stalk. (B) Megasporangiate strobilus: April 11 to May 15, upper = entire bud and strobilus, lower = bud scales partially removed to show base of strobilus and part of axis (*a*) bearing bud scales; May 22 and 29, strobilus with bud scales removed from right to show base of strobilus; (*b*) bract, (*sc*) ovuliferous scale. (C) Lateral vegetative shoot: by date, left = entire bud and shoot, right = bud scales partially removed to show base of shoot and part of axis (*a*) bearing bud scales; (*n*) needle, (*sh*) shoot.

in situ at the times of megasporangiate-bud measurement until after their pollen had been shed. On each collection date, up to the time of pollen release in 1968, two shoots bearing microsporangiate strobili were removed from each of the trees used for megasporangiate-strobilus collections. Five buds or strobili were taken from each shoot for dry-weight and moisture-content determinations.

Results

A. Strobilus Development

Late October, January, and March measurements of lengths and diameters of buds *in situ* indicated that there was no significant overwinter change in bud size. Bud swelling began in mid to late April in 1966 and in early to mid April in 1968. However, considerable development occurs within the buds before bud swelling. In the fall, when bud growth ceases, both the microsporangiate and megasporangiate strobili are shorter than the portions of the bud axes supporting them. Examinations of buds collected in mid January showed that this condition is maintained at least until then. By early April, however, the strobili have grown to about twice the lengths of the axes supporting them (Fig. 1A, B).

The gross changes occurring in microsporangiate and megasporangiate buds and strobili, and in lateral vegetative buds and shoots from the time of the beginning of bud swelling to the end of the period of megasporangiatestrobilus receptivity, are shown in Fig. 1. Drawings of lateral vegetative buds (Fig. 1C) are included to show the comparative development of each kind of lateral bud. In early April, the proportional volume of the buds occupied by strobilus or shoot is greatest in microsporangiate buds and least in vegetative buds. As the strobilus and shoot expand they force the outer bud scales in the upper part of the bud apart and carry overarching layers of inner bud scales between them (Fig. 1A, 1B, May 2; 1C, May 15). These inner, resin-free bud scales are later forced apart as the bud bursts. Occasionally inner bud scales, or portions of them, are broken off by the developing structure, but normally all bud scales remain attached to the axis. In 1968 the microsporangiate buds burst about 1 week before, and the vegetative buds about 10 days later than the megasporangiate buds. The bursting of the vegetative buds coincides with the start of pollen dehiscence.

Microspore mother cells were present in microsporangiate buds collected in early April, 1966. Tetrad formation was evident by mid April and many pollen grains possessed air sacs at the beginning of May. This was about 3 weeks before pollen shedding began.

Marked elongation occurs in the microsporangiate strobili just before pollen shedding. This results in some degree of separation of the microsporangia and in the development of a strobilus stalk (Fig. 1A, May 15; 22). The stalk serves to carry some of the lower microsporangia clear of the bud scales. Pollen grains are released through transverse apertures which form across the abaxial surfaces of the microsporangia.

The mature microsporangiate strobili vary in color from red-purple to yellow. The color is constant on any one tree and from year to year. All microsporangiate strobili turn brown after pollen shedding and then, over a period of months, fall from the trees leaving the bud scales on the shoots as cup-like remnants of the microsporangiate buds.

The early gross development of the megasporangiate strobilus (Fig. 1B) is characterized by vigorous growth and by striking changes in the bracts. Appearance of ovuliferous scales between the bracts (Fig. 1B, May 29) marks the termination of the receptive period. Bract and ovuliferous-scale development up to the end of the period of receptivity is shown in Fig. 2. The bracts are at first (Fig. 2, April 18) lanceolate and incurved. The mid-April bract length indicates an approximately sixfold increase over that at the time the bud becomes dormant. Subsequent elongation of the bract, and broadening in the basal half, result in the formation by mid May of an orbicular lamina surmounted by an acuminate awn. The lamina continues to increase in size, but the awn undergoes little additional growth. Figure 1B, May 15 and 22, shows how the bracts become strongly reflexed after bud bursting.

At the onset of bud dormancy, each ovuliferous scale occupies about one-third of the length of the subtending bract. By mid April, springtime growth has been such that each ovuliferous scale covers about one-fifth of the length of the subtending bract (Fig. 2, April 18). Sections cut from megasporangiate buds collected in early April, 1966, showed megaspore mother cells situated about four cells deep in the lateral adaxial portions of the ovuliferous scales (Fig. 3). During April and early May the megaspore mother cells increase in size, and divisions of the cells in the surrounding tissues result in enlargement of the ovules. By early May a nucellus becomes prominent in each ovule and integument initiation begins. Division of the megaspore mother cell occurs in mid May (Fig. 4). A cell wall forms between the first-formed daughter nuclei. In 1966, division of the daughter nuclei was evident on May 16 only in the cell closer to the micropylar end of the nucellus.

During the next week the axis of nucellus orientation changes from nearly horizontal to nearly vertical, with the micropylar end of the nucellus pointing downwards (Fig. 5). This change in orientation is associated with unequal lateral growth of the ovule and is accompanied by elongation of the integument and flaring of its extremity. By the start of the receptive period the inner surface of the flared portion of the integument is situated immediately above the upper surface of the ovule below (Fig. 5). As the period of receptivity progresses and strobilus growth continues, the distance between the integument and the surface beneath it increases.

The course of ovular development is shown in relation to that of the bract and ovuliferous scale in Fig. 2. It should be noted that development in 1968 (Fig. 2) was about 10 days in advance of that in 1966 (Figs. 3, 4, 5). The sequence of drawings in Fig. 2A shows how the integuments develop and grow over the edges of the supporting ovuliferous scale and point downwards. The early stages of nucellus and integument development are shown in lateral view in Fig. 2B, May 2 and 9. By mid May, when the bract is strongly reflexed (Fig. 1B), the flared

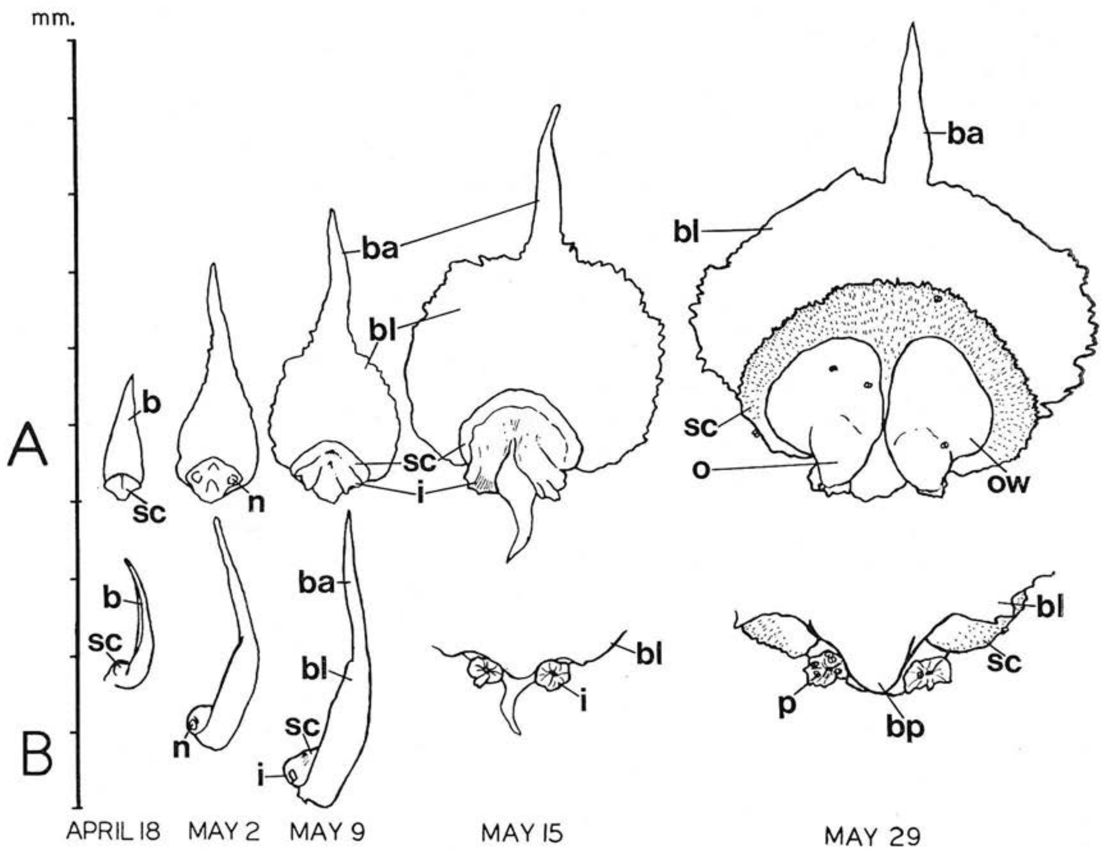

FIG. 2. Development of bracts and ovuliferous scales from the time of dormancy to the time of termination of the receptive stage (1968). (A) Adaxial side; (B) April 18 to May 9, side view; May 15 and 29, abaxial side of basal portion of bract and ovuliferous scale; (*b*) bract, (*ba*) bract awn, (*bl*) bract lamina, (*bp*) bract petiole, (*i*) integument, (*n*) nucellus, (*o*) ovule, (*ow*) ovule wing, (*p*) pollen grain, (*sc*) ovuliferous scale.

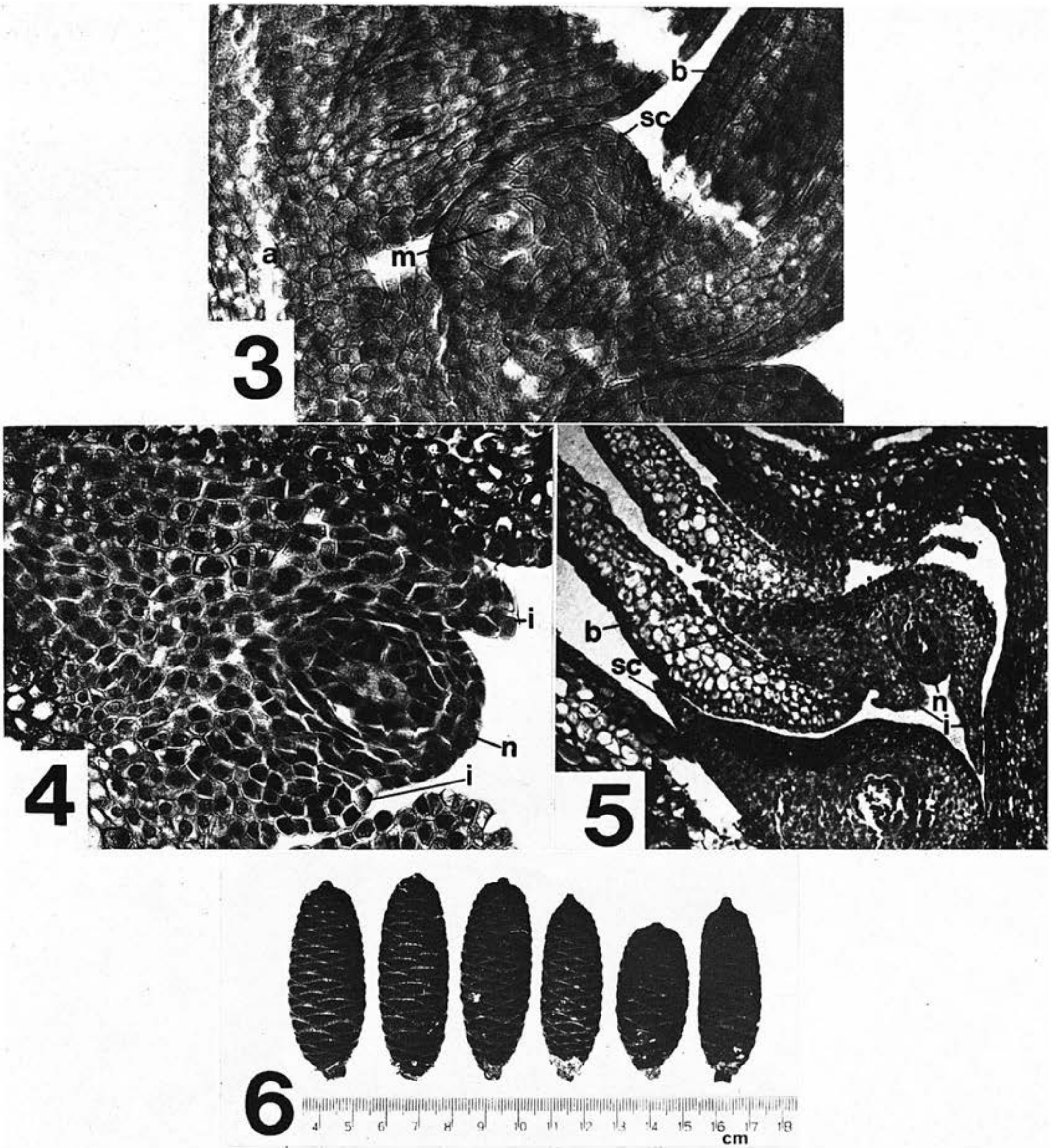

FIG. 3. Longisection through a megasporangiate strobilus showing an ovuliferous scale (*sc*) in the axil of a bract (*b*) and a megaspore mother cell (*m*) within the ovule tissue; (*a*) strobilus axis, April 4, 1966. × 340. FIG. 4. Longisection through an ovule showing integument (*i*) on the upper and lower sides of the nucellus (*n*) which contains the first daughter cells of the megaspore mother cell, May 16, 1966. × 290. FIG. 5. Longisection through a bract (*b*), ovuliferous scale (*sc*), and ovule showing nucellus (*n*) and integument (*i*) in receptive position, May 23, 1966. × 33. FIG. 6. Full-grown megasporangiate strobili from equivalent positions on each of six trees, July 11, 1966. Resin has been removed to show the nature of the apices of the strobili.

inner surfaces of the integument show conspicuously over the proximal edge of the abaxial side of each bract (Fig. 2B, May 15). Pollen grains were plentiful in the megasporangiate strobili in mid to late May, 1968. Most were found on the flared surfaces of the integuments, as in Fig. 2B, May 29. In late May the ovuliferous scales develop a dense white pubescence. The ovules, however, remain glabrous, and the extent of development of the ovule wing is thus clearly defined (Fig. 2A, May 29). Figure 2B, May 29, shows the beginning of development of a bract petiole.

Pollen grains which enter the receptive strobilus do so through apertures formed by the bracts (Fig. 1B). The lower side of each aperture is formed by the laminae of two adjacent bracts. The adjacent lateral margins of these laminae overlap to form a shallow V-shaped trough down which pollen grains are channelled. It is not known how the grains reach and accumulate (up to 40 have been counted) on the downward-facing flared portion of the integument. It is possible that air currents cause movement of pollen in the space below an integument. Whenever a grain hits the stigmatic flared surface (Doyle and Kane 1943), it is held there and thus pollen accumulates on the integument rather than on other surfaces.

The bracts continue to enlarge after the receptive stage, but growth of the laminae and awns is short-lived (Fig. 7). The bract petiole increases in length until early July. Soon after the receptive stage the bracts are overgrown by the ovuliferous scales (Fig. 7B, June 5; 19). As a result, the color of the strobili changes from the yellow-green to purple color of the bracts to the grey, blue, or deep purple color of the ovuliferous scales (the color of bracts and scales varies by tree.) Growth of the ovules and ovule wings (seeds and seed wings from early July) parallels that of the scales (Fig. 7A). Maximum strobilus

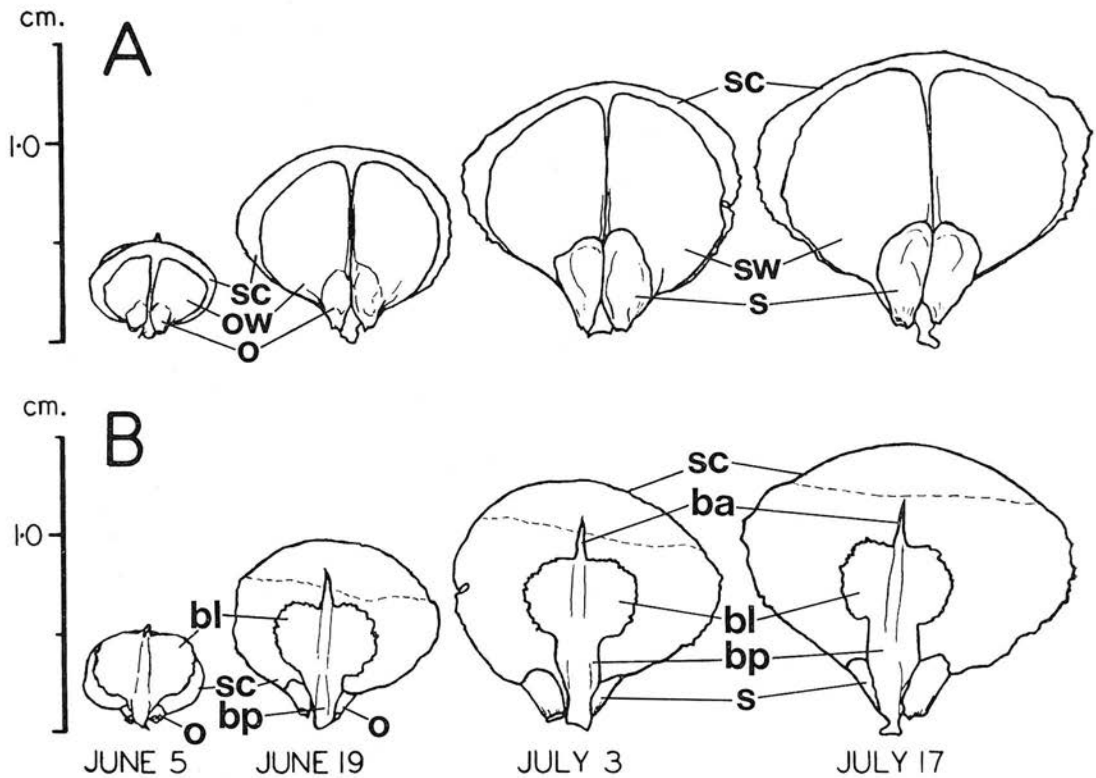

FIG. 7. Development of bract and ovuliferous scale from the time of strobilus closure to the time of achievement of full size. (A) Adaxial side; (B) abaxial side, the broken lines separate exposed parts (above line) from parts within the strobili; (*ba*) bract awn, (*bl*) bract lamina, (*bp*) bract petiole, (*o*) ovule, (*ow*) ovule wing, (*s*) seed, (*sc*) ovuliferous scale, (*sw*) seed wing.

size is achieved by mid July, at which time dimensional growth of all strobilus structures ceases. Full-grown strobili are shown in Fig. 6. From mid July through August the strobili gradually become brown. This color is first noticeable in the pubescence of the exposed parts of the scales.

During June, enlargement of the nucellus, thickening of the neck of the integument, and a reduction of the amount of flaring of the adaxial side of the integument tend to cause enclosure of pollen grains situated within and around the micropyle. By mid June some pollen grains rest on or near the exposed portion of the nucellus, the center of which is becoming cup-shaped (Fig. 8A). A raised margin is formed around the cup-shaped depression in late June. The depression is capable of holding about four pollen grains (Fig. 8B). Fertilization occurs in late June or early July, at which time the margin of the depression becomes brown and tends to close over the depression (Fig. 8C). Pollen tubes have been observed both inside and outside of the nucellar depression. In early July the integument extremities become brown and withered. By mid July, in 1966, the embryos were developing rapidly (Fig. 8D). The embryos had formed cotyledon primordia and occupied about half the length of the embryo cavity by July 24 (Fig. 8E). One week later embryos were found which completely filled the embryo cavity (Fig. 8F).

Strobilus disintegration begins at the end of August. Ovuliferous scales from the central part of the strobilus fall away from the axis first. Some seeds are blown loose singly, others remain attached to their subtending scales during dispersal. A knot of scales, held together by resin exudate, at the tip of the axis is frequently retained for a long period of time. Similarly, scales in the basal region may be held for several months. Most scales fall from the upright cone axis by mid winter.

B. Quantitative Aspects of Strobilus Growth

Growth in length, diameter, and dry weight of microsporangiate buds and strobili (Fig. 9A, B) follow the sigmoid form of growth curve. During pollen shedding, the strobili shrink in overall dimension. The dry weight of the strobilus decreases about 50% when the pollen is shed, indicating that the pollen grains make up about half of the dry weight of the mature strobilus. The moisture content (percentage of fresh weight) rises to about 80% at maximum strobilus size and falls rapidly as pollen is released.

Growth curves for length and diameter of megasporangiate strobili do not follow the normal pattern. In Fig. 10 it can be seen that the

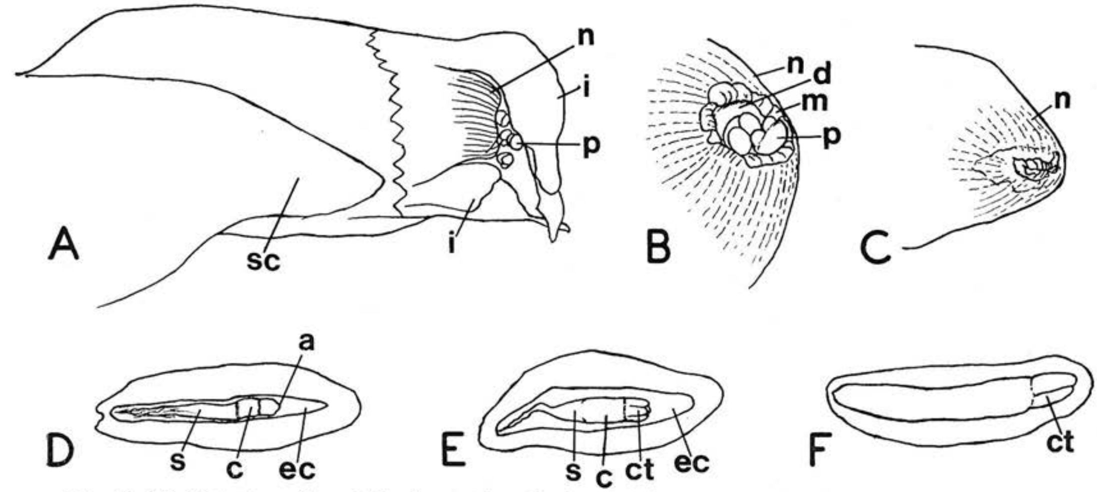

FIG. 8. (A) Side view of partially dissected ovule showing the micropylar end of the nucellus (*n*) and pollen grains (*p*) in the micropylar canal, (*i*) integument, (*sc*) ovuliferous scale, June 12, × 32. (B) Micropylar end of nucellus (*n*) with cup-shaped depression (*d*) surrounded by a raised margin (*m*) and containing two pollen grains (*p*), July 3, × 127. (C) Micropylar end of nucellus (*n*) with depression closed, July 10, × 32. (D) Longisection through nucellus showing embryo in embryo cavity (*ec*); (*a*) shoot apex, (*c*) calyptroperiblem, (*s*) suspensor, July 17, × 8. (E) Longisection through nucellus showing embryo with cotyledons (*ct*), July 24, × 8. (F) Longisection through nucellus showing embryo filling embryo cavity, July 31, × 8.

curves are of double sigmoid form. The initial surge of growth to the receptive stage is followed by a distinct slowing of the rate of growth before

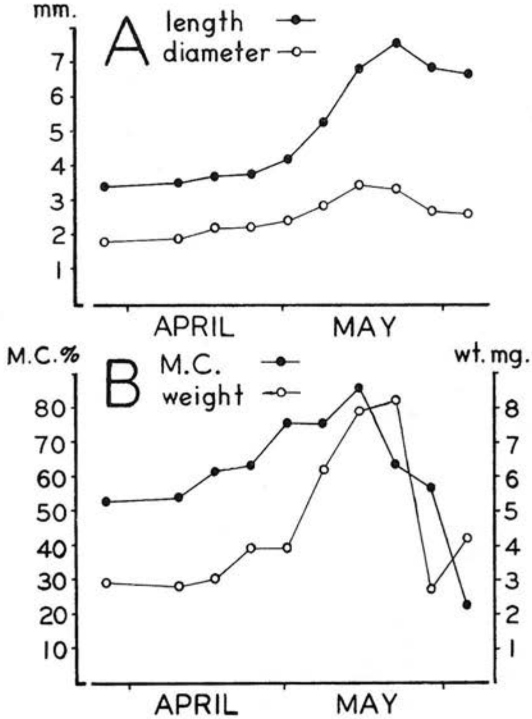

FIG. 9. Growth of microsporangiate buds and strobili, 1968: (A) length and diameter; (B) moisture content (M.C.) (percentage of fresh weight) and dry weight.

a second less rapid surge of growth occurs. This type of growth curve is not apparent when growth is expressed in terms of dry weight (Fig. 10). From the manner in which bracts and ovuliferous scales develop (Figs, 1, 2, 7) it is clear that the initial surge of strobilus dimensional growth is associated with rapid expansion of the bracts, while the second surge is associated with ovuliferous-scale growth. However, elongation of the strobilus axis occurs largely during the two distinct periods of rapid growth.

Figure 10 shows that strobilus dry weight continues to increase after cessation of dimensional growth of the strobilus. This late-season increase is accounted for largely by dry weight increases in the contained seeds; these increases are associated with embryo growth (Fig. 8D, E, F). Measurements indicate that the seed dry weight, expressed as percentage of strobilus dry weight, increases by about 10% from mid July to mid August.

The moisture content of megasporangiate strobili during development is also shown in Fig. 10. It rises, in the spring, in a similar manner to that of the microsporangiate strobili (Fig. 9B), to about 73%. This level is maintained until the end of June (the time of fertilization) when there is a slight rise in moisture content. This is followed by a steady decline until mid August, after which rapid drying occurs. Strobilus disintegration begins when individual strobili

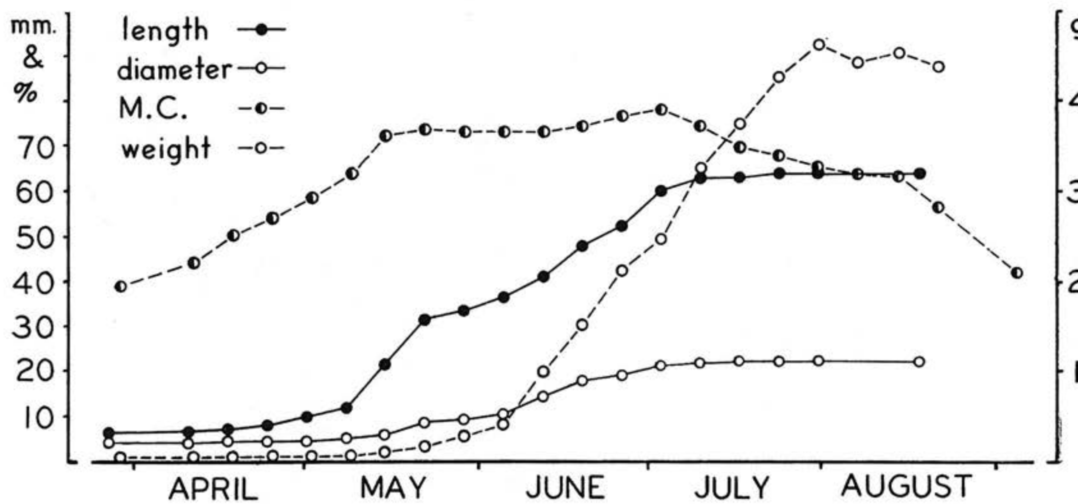

FIG. 10. Growth in length, diameter, and dry weight and moisture content (M.C.) (percentage of fresh weight) of megasporangiate buds and strobili, 1968.

reach a moisture content of about 40%. The moisture content of the seed falls more rapidly from early July through August than that of the strobilus as a whole. However, the rate of seed drying remains fairly constant before release. At the end of August the seeds have a moisture content of about 30%.

A total of 926 megasporangiate strobili were collected and dissected from six trees during 1966. The mean number of ovuliferous scales per strobilus varied from 121 on one tree to 157 on another. The overall mean was 141 (141.1 $\pm$ 1.7) of which 117 were classified as capable of bearing fully developed ovules. The average potential number of seeds per strobilus was thus 234.

The regular *in situ* measurement of marked buds and strobili on branches of different whorls on each of six trees provided data on bud and strobilus size. Data on final strobilus size are summarized in Table I. Although *t*-tests revealed significant differences between the means for whorls 2 and 3 only, it can be seen that there is a consistent decrease in both the length and the width of the strobili with increasing distance from the apex of the tree. Part of the relatively high standard errors indicated for the means can be attributed to the fact that strobilus sizes differ between trees. Also, owing to inequalities of strobilus bearing and to varying intensities of insect damage, the numbers of strobili sampled per whorl per tree was not constant. As many individual tree samples were small, the data were combined for presentation. The individual tree data, however, indicate that some significant differences occur between mean strobilus sizes for whorls 3 and 4 as well as between means for whorls 2 and 3. The decreasing-size trend is common to the strobili of each tree. Decreases of a similar nature also occur in the sizes of megasporangiate buds. Thus final strobilus size is positively correlated with bud size. For the strobili which provided the data for Table I the appropriate regression equations are:

$$\hat{Y}_l = -0.488 + 8.816X_l,$$
$$\text{and } \hat{Y}_w = 1.042 + 1.840X_w,$$

where $\hat{Y}_l$ equals the estimated final strobilus length, X_l equals the dormant bud length, $\hat{Y}_w$ equals the estimated final strobilus width, and X_w equals the dormant bud width. The standard deviations from regression are, respectively, 0.43 cm and 0.09 cm, and the coefficients of determination 0.780 and 0.742. Thus about 75% of the variation in final strobilus size is attributable to differences in dormant bud size.

TABLE I

Mean lengths and widths of fully grown megasporangiate strobili on different whorls in six trees, 1966

Whorl no. (from tree apex)	No. strobili in sample	Mean length with standard error, cm	Mean width with standard error, cm
1	13[a]	5.68±0.77	2.01±0.15
2	43	5.48±0.75	1.95±0.12
		*	*
3	50	5.07±0.96	1.83±0.18
4	23	4.82±0.93	1.80±0.20

[a]Strobili in whorl 1 were from four of the six trees.
*Significant difference between adjacent within-column means at the 1% level.

Discussion

Postdormancy development of the strobili of *Abies balsamea* begins before bud swelling is detectable by measurement. Before bud swelling, both microsporangiate and megasporangiate strobili increase markedly in size within the bud scales. In the former, microspore mother cells are present in early April. These undergo tetrad formation at about the time of the beginning of bud swelling. The development of the pollen grains, which are released about 5 weeks after bud swelling starts, is similar to that in several other *Abies* species (Mergen and Lester 1961; Kantor and Chira 1965; Ritchie 1966).

In early April megaspore mother cells are present in all ovuliferous scales in the central regions of the strobili. Each megaspore mother cell is situated, at that time, below three or four layers of cells. Further development up to the time of meiosis is similar to that in *A. pindrow* (Royle) Spach. (Dogra 1966). In *A. balsamea* the two nuclei resulting from the first division become separated by a wall; this is not the case in *A. pindrow*, in which the nuclei remain free until they undergo simultaneous division (Dogra 1966). Integument primordia form just before megasporangiate bud bursting, and the integuments are fully formed 2 weeks later when the receptive stage is reached.

Parke (1959) stated, for terminal vegetative buds of *Abies concolor* Lindl. and Gorde., that, as the shoot expands, the bud scales are torn loose and the resin-cemented scale complex is carried along on the developing shoot. This type of bud bursting does not occur in *A. balsamea*. The bud scales remain attached around the bases of the developing shoots or strobili; only in rare instances are bud scales torn loose.

The dimensional growth of microsporangiate strobili of *A. balsamea* follows the normal sigmoid form. However, that of megasporangiate strobili is double sigmoid in form. This type of growth curve was shown by Ritchie (1966) for megasporangiate strobili of *A. amabilis* and *A. procera*; it is less evident in the curves given for *A. sachalinensis* by Matsuura (1961). Ritchie (1966) termed the period between the two surges of growth the resting stage. However, this terminology is inappropriate since in *A. balsamea* it is clear that ovuliferous-scale growth is vigorous during this period and gains in dry weight are apparent. The first elongation phase can be associated with bract-lamina growth, the second with ovuliferous-scale growth. The separation in time between the grand periods of growth of bracts and ovuliferous scales facilitates the achievement of a condition suitable for the entrapment of pollen. Similar phasing of the grand periods of growth of bracts and scales is indicated in *Larix* (Barner and Christiansen 1960; Hashizume and Imai 1966) and *Pseudotsuga* (Barner and Christiansen 1962; Ching and Ching 1962; Owens and Smith 1965). In these genera, as in *Abies*, the pollen grains enter the strobilus between bracts. In this regard, Bakuzis and Hansen (1965) indicated erroneously that pollen grains of *A. balsamea* are caught between ovuliferous scales and that the bracts are minute in comparison to the scales.

Doyle and Kane (1943) described the manner in which changes occurring in the integument and nucellus in *A. nordmanniana* (Stev.) Link. and *A. koreana* Wilson result in the nucellus gaining contact with pollen grains. The process is basically similar in *A. balsamea*, but some details differ. The general shape of the micropylar end of the nucellus remains rounded, rather than becoming wedge-shaped, and a raised margin develops around the depression in the nucellus. The depression accommodates about four pollen grains which presumably gain an advantage in effecting syngamy over those remaining outside the depression (cf. Sarvas 1962, 1968). Doyle (1945) suggested that two developmental lines of pollination mechanism are apparent in the Pinaceae. Each has developed from early coniferous forms in which he considered fluid to have been involved in the transference of pollen grains to the nucellus. This feature is retained in the basal elements (*Pinus* and *Picea*) of one line; in the other, in which *Abies* occupies the basal position, involvement of fluid is lacking. It is perhaps significant that the moisture content of the megasporangiate strobilus of *A. balsamea* rises to its maximum value during the period in which pollen grains come in contact with the nucellus.

The sizes of both megasporangiate buds and strobili of *A. balsamea* decrease with increasing distance from the apex of the tree's crown. This is in agreement with the findings of Lyons (1956) and of Winjum and Johnson (1964) for the strobili of *Pinus resinosa* Ait. and *Pseudotsuga menziesii* (Mirb.) Franco. respectively. The decrease in strobilus size is similar in nature to decrease in shoot length with distance from the tree's apex. Fraser (1962) related the latter, in *Picea glauca* (Moench.) Voss., to varying auxin levels in the terminal buds of shoots situated at different elevations in the crown.

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